The role of family support on adolescents suffering from major depressive disorder

by

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Declaration

I Vidoh Masilo declare that this dissertation for the degree of Master of Social Science (Clinical Psychology) in the department of Psychology in the faculty of Human and Social Science at the University of North West has not previously been submitted by me for a degree at this or other university, that is my own work in design and execution and all material contained herein has been duly acknowledged.

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Abstract

Adolescent depression must be evaluated in the context of precipitants, stressors and academic, social and family functioning. Depression in adolescents can interfere with normal developmental tasks that involve academic, social and family functioning. Family support is partially important in the normal development of young people. The present study investigated the impact of family support among depressed adolescents.

There has been increasing emphasis on interpersonal factors in adolescents' depression that contribute to recurrence of depression. There is no single unifying social model of depression but rather various theoretical developments that emphasize interpersonal cognitions and behaviours. Depressed individuals often function poorly in relationships with family members. However, negative attitudes by family members may precipitate relapses.

A survey was conducted to explore the impact of family support on depressed adolescents. A sample of 50 depressed adolescents was randomly selected from Weskoppies Adolescent Unit in Pretoria. There were equal numbers of males and females with ages ranging from 12 to 20 years. The mean age was 15.7 years. The research instruments consisted of the Differential Loneliness Scale, Beck Depression Inventory and Family Functioning in Adolescents' Questionnaire.

The main finding of the study was that the depressed adolescents showed social isolation from family members. Experts say social isolation for depressed patients is distressingly common. However, previous researchers have found that social isolation may allow a depressed person to worsen dramatically without intervention. The study did not support the hypothesis that adolescent with poor family relationship show higher levels of depression than those with good family relationship. This may suggest that family environment has a big impact on

adolescent development. It has been reported that depressed children who live in families with high level of chronic conflicts are more likely to have relapses. There were no significant differences between male and female adolescents' level of depression. Factors such as social experiences and psychosocial stressors play an important role in adolescent' depression. Therefore, both male and female adolescents' level of depression depend on psychosocial and cognitive explanations.

The findings in the study had several implications: As family relationship had no significant relation with adolescent depression, the findings revealed that family environment was a critical factor in adolescent development. These finding also suggest important guidelines for preventing adolescent depression. The study also demonstrated the importance of how male and female adolescents deal with stress, as that might lead to depression. The study can also be used as a guide for therapeutic interventions with a depressed adolescent.

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1.1 Introduction

Everyone feels "blue" at certain times during his or her life. In fact transitory feelings of sadness or discouragement are perfectly normal, especially during particularly difficult times. But a person who cannot snap out of it" or get over these feelings within two weeks may be suffering from the illness called depression.

All of us experienced moods involving depression or elation at some time during our lives. Ordinary people experience a wide range of moods and have an equally large repertoire of affective expressions; they feel in control, more or less, of their moods and affects (Steinberg,2001). . Mood disorders are disturbances in emotions that cause subjective discomfort, hinder a person's ability to function, or both.

Depression is the most common mood disorder, and it occurs so often that it has been called the "common cold of psychological disorder" in mood disorders, the sense of control is lost, and people experience great distress. Depression is characterized by intense sadness, feelings of futility and worthlessness, and withdrawal from others (Kaplan & Sadock, 1998).

Clinical depression is a serious illness that affects most, if not all, facets of a depressive's life. The major component of depression is a loss of interest in activities once found pleasurable. In fact, in order for a person to be diagnosed with having Major Depression disorder, a loss of interest in activities once found pleasurable must be present (Beyers & Goossens, 1999)

It's not unusual for young people to experience "the blues" or feel "down in the dumps" occasionally. Adolescence is always an upsetting time, with the many physical, emotional, psychological and social changes that accompany this stage of life. Many young people feel that life is not fair or that things "never go their way". They feel "stressed out" and confused. When teens' moods disrupt their ability to function on a day-to-day basis, may indicate a serious emotional or mental disorder that needs attention, it is adolescent depression.

Depressed mood is more prevalent during adolescence. Depression in children and adolescents must be distinguished from the "normal" blues and emotional distress that is typical at various developmental stages. The symptom of depressed mood or sadness is not the same as depression as a disorder. A depressive disorder refers to a pattern of behaviours that pervasive, persistent and disruptive to normal functioning, typically interfering with social activities and interests, academic pursuits, family life, and personal satisfaction.

Not all adolescents will show all symptoms and most will display different symptoms at different times in different settings. Although some adolescents may continue to function reasonably well in structured environments, most youth with significant depression will display several indications of decreased functioning, most commonly showing a change in social activities, decreased academic interest and performance, or a change in appearance (Lewinsohn et.al.,1998).

The teenage years are a period of turmoil for just about everyone. You're learning new social roles, developing new relationships, getting used to the changes in your body, and making decisions about your future. And when you're looking for answers to problems, it can seem like no one has them. That can make a person feel quite alone. Teenagers experience strong feelings, confusion, self-doubts, pressure to succeed, and other fears when growing up (Beyers & Goossens, 1999).

In children and adolescents, the most frequent diagnosed mood disorder is Major Depressive Disorder. Major Depressive Disorder is a serious condition characterized by one or more major depressive episodes. Depressed children are said, they loose interest in activities that used to please them, and they criticize themselves and feel that others criticize them. They feel unloved, pessimistic, or even hopeless about the future, they think that life is not worth living, and thoughts of suicide may be present (Birmaher ,Brent & Benson, 1996).

Depressed children and adolescents are often irritable, and their irritability may lead to aggressive behaviour. They are indecisive, have problems concentrating, and may lack energy or motivation, they may neglect their appearance and hygiene, and their normal sleep patterns are disturbed (DSM-IV). Adolescent's moods are especially vulnerable to influences of severe social stresses, such as chronic family discord, abuse and neglect, and academic failure (Kaplan & Sadock, 1994).

Depression is an illness that has profound input on family members who leave with the person as love the person. Depression is an illness that takes many shapes and forms. Some depressed people show subtle signs and symptoms for months before they are officially diagnosed and treated in this early phase can be difficult for everyone in the family. Some people who are depressed withdraw from people and isolate themselves. Some people start drinking heavily and isolate themselves. Some become irritable and moody and have angry, eruptive outburst. These behavioural changes can be mystifying for family members who do not know reason for the change (Kaplan & Sadock, 1998). Also, it is extremely upsetting to be around someone who is withdrawn morose or angry a great deal.

Families are profoundly affected by the presence of a member with Major Depression disorder. The support and involvement of family and friends can play a crucial role in helping someone who is depressed. Living with a depressed person can be very difficult and stressful on family members and friends. The

pain of watching a loved one suffers from depression can bring about feelings of helplessness and loss (Husain, 1990).

Individuals in the "support system" can help by learning more about depression so that they can identify constructive ways of supporting a loved one who is suffering from depression. Depression can seriously impair a person's ability to function in everyday situations. But the prospects for recovery for depressed individuals with family support system are very good (Husain, 1990). By receiving support from family members, people suffering from depression can help regain control of their lives.

1.2 Problem statement

This study is concerned with the experience of mood swings that adolescents undergo and the impact of family support during that turmoil period.

Recently, mood disorder among children and adolescents have been increasingly recognized and treated. Although people have also realized that children and adolescents undergo sadness and despair, it has become clear that enduring disorders of mood occur in children of all ages and under many different circumstances. Developmental issues, however, influence the expression of all symptoms. Children with depressive disorder in midst of toxic environment may have remission of some or many depressive symptoms when the stressors diminish or when the children are removed from the stressful environment (Ryan Puig-Antich & Ambrosini, 1987).

Depression is an illness that can often afflict numerous people in a family system. Depressive episodes can be triggered by stressful event. This psychosocial event can play a powerful role in the onset of depressive illness. So, not only does he family have to deal with the very real problems in life, but they also have

to deal with a depressed person. When family members are perplexed and confused about why their relative is behaving differently, hey may become angry at each other and family problems may get exacerbated (Shiner & Marmorstein, 1998). It has been in numerous research studies that family problems cannot only precipitate depressive episodes but that ongoing family friction can impede recovery from depression.

1.3 Significance of the study

The purpose of this study is to examine the impact of family support among adolescents suffering from Major Depressive Disorder. The study will also enlighten the family and the community on the insight about what happens during adolescence. This will help alleviating unnecessary stressful reactions, which threaten the well being of our society.

It is the purpose of this study to improve the relationship between the family and their adolescents. Modernization and technocratic world contribute to generation gap between parents and their teenagers. This signifies that the project intends to bridge the gap created by cultures of generations without exterminating them. This study aims at making adolescents aware that this stage is normal course of development and that when they experience overwhelming difficulties it would be important to seek information or help.

1.4 Objectives of the study

To provide developmental stages of adolescence

To explore important intervention strategies which can be used in helping adolescents who suffer from Major Depressive Disorder

To provide insight with respect of helping parents, family members and others in identifying and assisting adolescents who experience depression

To improve quality relationship between parents and their adolescents and to suggest provision of knowledge and education about becoming and development of adolescents

1.5 Statement of hypothesis

1. Adolescents with poor family relationship show higher levels of depression than those with good family relationship.

2. Depressed adolescents will show social isolation from family members.

3.There are significant differences between male and female adolescents' level of depression

Motivation of the study

Adolescents handle stressors with varying degree of mastery, some do well, others, who have not developed appropriate and successful coping skills, may suffer from stress-related disorders. They may express their stress in such maladaptive and negative ways as eating disorders, substance abuse, sexual promiscuity, suicide attempt, depression and other mental and physical illnesses (Husain, 1990).

The health and social welfare of the youth is one of the major areas of concern for South Africa because the youth is the future investment of society. In order to avert catastrophic consequences of adolescent's negative attempts to deal with

all the changes confronting them, and also with the confusing and sometimes rather discouraging conditions that constitute the reality they have to live with, parents, family and others concerned, must help adolescents to develop a more successful method of dealing with stress.

Although it would not be easy, or even wise, to eliminate all sources of stress, the negative effects of stress can be controlled and seduced (Schaffer & Craft, 1996). By identifying the symptoms of stress and recognizing these as cries for help, parents, family members and others concerned with the welfare of youth can help these young people to develop appropriate coping strategies and by this prevent further negative consequences (Krug, Kresnow & Peddicord, 1998)

Emphasis will be placed on the role of both parents and family members in preventing excessive stress in adolescents and assist in the adolescents and assisting the adolescents suffering from depression.

1.6 Definition of Concepts

Adolescence:

Based on Louw (1991) conceptualization, adolescence is the developmental stage between childhood and adulthood, between dependence and independence.

The term adolescence is derived from the Latin verb adolescere, which means to grow up or to grow to adulthood.

The age at which adolescence begins varies from 11 to 13 and at which it's ending varies from 17 to 21, because of cultural differences.

Erikson (1977) regards adolescence as period of acquisition of a sense of self-identity while overcoming a sense of identity diffusion.

Family:

A set of people related by blood marriage of adoption who share the primary responsibility for reproduction and caring for members of society (Schaffer & Craft, 1999)

Family Support:

The availability and quality of interpersonal resources from the family that family members can call on during emotional distress

Mood Disorders:

Severe disturbances of mood or effect that cause subjective discomfort hinder a person's ability to function, or both. Mood disorders involve depression, on mania or both.

Depression:

An emotional state characterized by intense dysphoria, sadness, feelings of futility and worthlessness, and withdrawal from others.

Major Depression disorders:

Include a core symptoms of dysphoric mood or loss of interest plus at least four of the following symptoms: - sleep disturbances, appetite disturbance, weight loss, psychomotor retardation, suicidal ideation, poor concentration, feelings of guilt, and a loss of interest in usual activities.

It involves depressive episodes that disrupt ones ability to sleep, eat, work, and enjoy life.

CHAPTER 2
LITERATURE REVIEW

Although most contemporary researchers o longer support the view that adolescence is inevitably a period of "storm and stress" (Brent, Holder & Kolko, 1997), parents, family and psychologists agree that adolescence is a difficult period of human life cycle, while puberty heralds a time of special stress (Brown, Mounts & Lamborn, 1993). The main reason for this may be the large number of biological, cognitive, affective and social changes experienced by adolescents (Keitner, Ryan, Miller, Kohn, Bishop & Epstein, 1995).

Depression and suicidal behaviour in children and adolescents has been a topic of controversy for decades, with the disorder in youth not recognized by the medical community until the 1970s.Recently, research and clinical writing have focused on appropriate diagnosis of children with affective (emotional) disorders, identification of those at risk for mood difficulties, and investigation of effective interventions.

Further, during adolescence important cognitive changes occur as the concrete, literal thinking of the child gives way to more rational thinking of the adolescent (Kovacs, 1992). This new way of thinking is characterized by a progressive differentiation of thought and a conception of reality. Through inductive reasoning, adolescents systematize ideas critically with their own thinking (Monroe, Rohde & Seeley, 1999). They therefore develop an increasing ability to act autonomously and independently. However, this newly acquired independence often leads to conflict between adolescents and their parents, as well as between them and their teachers. Together with the transition from the independence and autonomy of adulthood, adolescents are faced with the challenge of developing new, mature, relationships with their parents, peer and teachers (Reinecke, Ryan & DuBois, 1998).

Adolescence is the development state between childhood and adulthood. The term " adolescence" derives from the Latin verb Adoloscere, which means " to grow up " or to grow to adulthood (Shaffer, Goud & Fisher, 1996). Because of individual and cultural differences, the age at which adolescence begins varies from 11 to 13 and the age at which it ends varies from 17 to 21. Since the age boundaries of adolescence are variable, it is better to demarcate the various developmental stages of adolescence on the basis of specific developmental characteristic rather than age. Adolescence therefore begins during puberty – that is when the rapid physical growth begin, the production organs begins to function, sexual maturity is reached and secondary sexual characteristics appear (Geller, Reising & Leonard, 1999).

2.1. ADOLESCENCE

2.1.1. Defining adolescence

What is adolescence? The Latin root of the word is esso, which means, "becoming". The term is used to describe the period from puberty's onset to the beginning of adulthood. In our culture this period can be described as a span of years, a stage of growth, a subculture, a state of mind or all of the above (Masche & Barber, 2001).

In many other cultures, adolescence is not recognized as a distinct stage of life at all. Young people move directly from childhood to adulthood, with the transition marked by some formal rite of passage. The term adolescence was invented to describe this in-between period in which young people are neither children nor adults.

2.1.2. Developmental stages of teens

2.1.2.1. Physical changes

Adolescents experience rapid rates of growth and maturation of the reproductive organs and glands. Together, these physical changes accomplish the biological task of transforming a child into an adult. Rapid change combined with wide variation among individuals tends to make adolescents extremely sensitive to their appearance. At no other time in life are feelings about the self (self-esteem) so closely tied to feelings about the body (body image).

These physical changes also affect their social relations and emotions. That is why a pimple or being ahead or behind a classmate in physical growth can be so stressful to the teens' emotions (Weissman, Fendrich, Warmer & Wickramante, 1992)

i. The psychological effects of physical changes

Adolescents are acutely aware of the physical changes they experience. An important developmental task during adolescence is the acceptance of a changed physical appearance. However, this acceptance is not always easy for all adolescents. For many boys, the lowering of the voice could cause embarrassment, when in the midst of a serious conversation, their voices suddenly squeak and crackle. Girls are usually concerned about their sudden weight increase, although cultural differences do occur. In most western cultures, however, a slender body is the norm. For some adolescents, the attainment of this norm is so important that it can lead to eating disorders or mood disorders.

2.1.2.2. Mental changes

Teens develop their abstract thinking capacities. Before age 11 or 12 children think in terms of concrete objects and groups of objects. By age 16 most adolescents have gone from the simple way of thinking to complex forms of

reasoning. They learn to approach a problem systematically. Moral issues become more complex because they understand that in certain situations the values of friendship and honesty conflict. They will struggle with a question about whether someone should report a friend for breaking a rule.

Teens also come to realize that what exists is only one of many possibilities. This is important in facing many choices as they move into adulthood and choose career directions, educational paths and mates (Rao, Hammen & Daley, 1999). Thus, teens need time alone to think about the many possibilities.

2.1.2.3. Social changes

Because of their physical and mental growth, adolescents are no longer treated like children. The expectation adults and peers have of them change and their behaviour changes. Thus the social world in which they live changes them in important ways.

One of the most obvious social changes is the beginning of serious interest in and interactions with teens of the opposite sex. They have to learn to handle the emotions and behaviour that go along with these relationships. They also experience a change in how adults treat them and talk to them (Kalsow, Deering & Racusin, 1994). It is often in a more adult manner. They are also seeking more independence. They are given more privileges that were reserved for adults like driving and working. However, they may feel they should have even more privileges and these may become areas of conflict for parents and teens. Parents may feel frustrated with the perception that teens want more freedom but not the responsibility that comes with it.

2.1.2.4. Psycho-social development

There are five recognized psychosocial issues that teens deal with during their adolescent years (Rosenberg, 1965).

i. Establishing an identity

This has been called one of the most important tasks of adolescents. The question of "who am I" is not the one that teens think about at a conscious level. Instead, over the course of the adolescent years, teens begin to integrate the opinions of influential others into their own likes and dislikes. The eventual outcome is people who have a clear sense of their values and beliefs, occupational goals, and relationship expectations. People with secure identities know where they fit in their world.

ii. Establishing autonomy.

Some people assume that autonomy refers to becoming completely independent from others. They equate it with teen "rebellion". Rather than severing relationships, however, establishing autonomy during the teen years really means becoming an independent and self-governing person with relationships (Ryan et al., 1987). Autonomous teens have gained the ability to make and follow through with their own decisions, live by their own set of principles of right and wrong, and have become less emotionally dependent on parents. Autonomy is a necessary achievement if the teen is to become self-sufficient in society.

iii. Establishing intimacy

Many people, including teens, equate intimacy with sex. In fact, intimacy and sex are not the same. Intimacy is usually first learned within the context of same-sex friendships, then utilized in romantic relationships. Intimacy refers to close relationships in which people are open, honest, caring and trusting. Friendships provide the first setting in which young people can practice their social skills with those who are their equals (Ryan et al., 1987). It is with friends that teens learn how to begin, maintain, and terminate relationships, practice social skills, and become intimate.

iv. Becoming comfortable with one's sexuality

The teen years mark the first time that young people are both physically mature enough to reproduce and cognitively advanced enough to think about it. Given this, the teen years are the prime time for the development of sexuality. How teens are educated about and exposed to sexuality will largely determine whether or not they develop a healthy sexual identity. More than half of most high school students report being sexually active. Many experts agree that the mixed messages teens receive about sexuality contribute to problems such as teen pregnancy and sexually transmitted diseases (Wells, Deykin & Klerman, 1985).

v. Achievement

Our society tends to foster and value attitudes of competition and success. Because of cognitive advances, the teens are a time when young people can begin to see the relationship between their current abilities and plans and their future vocational aspirations (Wells et al., 1985). They need to figure out what their achievement preferences are what they are currently good at and areas in which they are willing to strive for success.

2.1.3. Identity formation

Identity refers to the individual's awareness of himself or herself as an independent, unique person with a specific place in society. Although identity development begins during infancy and continues till the end of the life cycle, the greatest degree of identity development occurs during adolescence. This is because of profound physical, sexual, cognitive, social and moral development. The integration of these developments is therefore an important developmental task of adolescents in order to develop an identity.

The development of an identity seems to a universal requirement of adolescence, although specific way in which an identity is established will differ from culture to culture (Erikson, 1977).

2.1.3.1. Erikson's psychosocial theory of development

Erikson (1977) explained development in eight stages from birth until old age. The stage that best describes the depression that the teenager undergoes is the adolescent stage. This stage is characterized by identity formation versus role-confusion.

2.1.3.2. Adolescence: Identity versus Role confusion

Erikson studied the concept of identity formation as the most important aspect of this stage. Erikson (1977) defined identity as the "organized set of images and sense of self that express who and what we really are " (Noom, Dekovi & Meeus, 1999). Identity development depends on our physical stage, our encounter with society and societal roles we play and our internal ordering of these experiences. Erikson believed that the tusk of establishing one's identity is especially critical during this stage because of the change in physical maturation and society's demands on adolescents.

This stage starts with the onset of puberty and ends with the beginning of maturity, that can be anywhere between 12 and 24 years, depending on the culture. Youth must be able to redefine themselves but this process may create an identity crisis. For others, the stage creates a temporary period of uncertainty that passes as a new sense of identity develops. For others still this period can be a time of emotional turmoil and even massive personality disorientation (Brown, Cohen & Johnson, 1999).

The concept of ego identity is one of the most important contributions Erikson has made to psychology. Ego identity can be defined as the individual's image of himself, including the feeling that a threat of continuity runs through ones life and that one self-image and the view others have of him are essential in agreement (Hammen, 1991). The individual has a sense of identity when he manages to integrate all his identification, his drives, wishes and expectations, abilities and skills with the opportunity his society offers him. This quest for identity often causes the young adolescents to clash with the rules of society and with persons who are close to him or her, such as parents. The danger of this stage is that the adolescent may be confused in the search for identity and a suitable social role. Typical adolescents behavioural patterns such as participation in-group activities; falling in love and the pre-direction of youth movements are part of the search for identity.

Hammen (1992) claim that society accommodates the adolescent search for identity by providing a psychological moratorium, which is a period of grace for youth to pursue their quest for identity relatively undisturbed. This is a period in which the adolescent is allowed to experiment with various identities. Society is not only exceptionally tolerant of adolescent behaviour, but also provides active support in the form of social institutions such as universities, colleges, tribal school, military services and extended vocational training. Erikson calls the ego gain than results from a satisfactory resolution of the identity crisis reliability of fidelity. This ego strength is characterized by certainty about one's own identity, an awareness of other possible identity choices which one could have made and a capacity for loyalty towards one's social roles.

Kovacs et. al., (1984) explained the process of forming an 'ego identity" as one that requires one to comparer how one sees oneself with how significant others appear to expect one to be. Ego identity, then, is a subjective aspect, an awareness of the fact that there is a self-sameness and continuity to the ego synthesizing methods and continuity of one's meaning for others. According to

Steinberg (2001) ego identity results in a sense of "coherence in individuals" that enables one to resolve one's conflicts adaptively. The danger of this stage is that the role confusion i.e. the inability to conceive of oneself as a productive member of one's society.

a) Role confusion

Identity confusion occurs when adolescents are indecisive about themselves and their roles. They cannot integrate the various roles, and when they are confronted by contradictory value systems, they have neither the ability nor the self-confidence to make decisions. This confusion causes anxiety, depression, as well as apathy or hostility towards roles or values. This identity confusion could also result in an identity foreclosure or negative identity (Erikson, 1977).

i. Identity foreclosure

This means that the identity crisis is resolved by making a series of premature decisions about one's identity, based on others' expectation of what one should be. This happens when external demands or role expectations pose a threat to adolescents' identity development. In their confusion, they then tend to fulfill roles simply to meet the expectations of others, without really identifying with these roles (Steinberg, 2001).

ii. Negative identity

This means that adolescents form an identity contrary to the cultural values and expectations. Examples of such adolescents are drug abusers and juvenile delinquents.

Roles confusion usually arises out of the adolescent difficulty of finding an occupational identity, but it may also express a general inability to find a meaningful place in one's culture. The adolescent who cannot find a meaningful adult role runs the risk of an identity crisis, a transitory failure to establish a stable identity. Some young people may drop out of society for a short period of time as

Erikson (1977) himself did. Some may adopt a negative identity, one that is opposed to the dominant values if their upbringing, (Carnelley et. al., 1994).

The ritualization of this stage is ideology. Ideology indicates a readiness to assume a constructive role in technological and political system of one's culture and to commit oneself firmly to its values. The young person is able to engage actively in those rites and ceremonies, be they of religious, national or military nature, which reflect the ideological commitments of society. The corresponding ritualistic element is totalism, which is a fanatical and exclusive preoccupation with what seems to be right and that excludes any point of view.

Papalia & Olds (1992) describe the identity formation in adolescents. The chief talk of adolescents is to resolve the conflict of identity versus role-confusion, to become a unique adult with an important role in life. The search for identity is life-long; it comes into focus during adolescence and may recur from time to time during adulthood. The conflicts involved spur growth and development. One of the dangers is identity confusion. However, a certain amount of identity confusion is normal and necessary and accounts for the chaotic, volatile character of much adolescent behaviour as well as self-conciseness about appearance. Cliquishness and intolerance of differences both hallmarks the adolescent social scene and also defenses against confusion.

2.1.3.3. Freud's theory on development

Sigmund Freud saw conflict as a result of the physical changes of adolescence. In Freud's view, this conflict is preparatory to the genital stage of mature adult sexuality. The physiological changes of puberty reawaken the libido, the basic energy source that fuels the sex drive. To achieve mature sexuality, adolescents must overcome their unresolved sexual feelings toward the mother or father. Through the defense mechanism of reaction formation, expressing the opposite of what one really feels, adolescents replace sexual longing with hostility (Kaplan

& Sadock, 1998). Thus, Freud also saw storm and stress as inevitable in adolescence, part of a phenomenon known as adolescent rebellion.

2.1.3.4. Kohlberg's moral development

In kohlberg's theory, moral reasoning is a function of cognitive development. Moral development generally continues in adolescence, as the ability to think abstractly lets young people understand universal moral principles. According to Kohlberg, advanced cognition must exist for moral development to take place.

The development of moral reasoning and judgment progresses through three levels, each consisting of two stages. These levels are; the preconventional level, the conventional level and the postconventional level. Not everyone reaches the highest level of moral development (Papalia & Olds, 1992).

Most adolescents, like most adults are at Kohlberg's level two, i.e. the conventional level. This level is also referred to as the morality of conventional role conformity. This means that the individual conforms to the social order and the expectations of others. The two stages that can be distinguished at this level are: morality of interpersonal expectations and morality of social systems and conscience.

In the first developmental stage, persons see good behaviour as behaviour that other people approve of. They attempt to maintain the affection of friends, family and significant others by being a good person (Kalsow et. al.1994). In the second stage, correct behaviour is associated with doing one's duty, respect for authority, and with the upholding of existing social law and order. Individuals in this stage believe that society's laws must be enforced in the same way for everyone. An act is wrong if it violates society's laws or rules or if it harms someone (Papalia & Olds, 1992).

Kohlberg's emphasis on the cognitive basis for moral judgment also seems to be justified. Moral development has been positively correlated with IQ and educational level. This means that as IQ increases and educational level improves, the higher the levels of moral development (Papalia & Olds, 1992). Several studies have indicated a positive relationship between IQ performance on Piagetian-type cognitive tasks and moral development. In South Africa, Beard (1988) also found a significant relationship between intelligence and the level of moral development in his sample of Indian, White, Black and Coloured adolescents.

However, this does not mean that only people with high IQs can reach the higher levels of moral reasoning, but only that cognitive development is necessary for moral development.

2.2. ADOLESCENT DEPRESSION

2.2.1. Major Depressive Disorder

Major Depressive disorder (MDD) is characterized by a history of one or more major depressive episodes in the absence of manic, hypomanic, or mixed episodes of mood disturbances. To meet DSM-IV criteria, the adolescent must display at least five depressive symptoms:

- Depressed or irritable mood
- Markedly diminished interest or pleasure in almost all activities
- Change in appetite or weight
- Insomnia or hypersomnia
- Psychomotor agitation or retardation
- Fatigue or loss of energy
- Feelings of worthlessness or guilt
- Impaired concentration, indecisiveness
- Recurring thoughts of death or suicide

One of the symptoms must be either depressed mood or loss of interest or pleasure that is present for most of the day, nearly every day, for at least weeks, with the remaining symptoms present during the same period. The symptoms must cause clinically significant distress or impairment and represent a change from previous functioning (DSM-IV, 1994).

The clinical presentation of childhood and adolescent depressive disorder parallels the phenomenology of depressive disorder in adults. However, some developmental differences exist, and informed clinical judgment often is needed to translate an adolescent's manifestation of symptoms into DSM-IV criteria.

2.2.2. Phenomenology

To clarify the phenomenology of depression in adolescents, each criterion for a major depressive episode is reviewed below with a focus on typical adolescent manifestation.

Depressed or irritable mood- many adolescents directly report a depressed mood, such as feeling down, sad, or blue much of the time. However, depression in adolescents commonly expresses itself primarily as an irritable mood. The DSM-IV provides the "irritability" criterion only for children and adolescents because many adolescents and most children lack the emotional and cognitive sophistication to correctly identify and organize their emotional experiences. Irritability, for example, often manifests in the adolescent's being "annoyed" or "bothered" by everything and everyone. Rather than expressing sadness, the depressed adolescent may be moody, negative, and argumentative. He or she often is unable to tolerate frustration and responds minor provocations with angry outbursts (Hammen & Rudolph, 1996).

a) Depressed mood in adolescents may manifest as:

- Finding others antagonistic or uncaring
- Brooding about real or potentially unpleasant circumstances
- A gloomy or hopeless outlook
- Belief that everything is "unfair"
- Feelings that they disappoint parents or teachers.

Mood reactivity, the capacity to be cheered up when presented with positive events, is common in adolescents and a characteristic feature of depression with atypical features. Mood reactivity can cause adolescents to seek activities and experiences to temporarily lift their moods. Examples of these activities include affiliation with peers, thrill-seeking and drug-use. The use of peer affiliation to alleviate depression is differentiated from the normal adolescent need for peer affiliation by its urgency and drivenness (Steinberg, 2001).

b) Diminished interest or pleasure

Anhedonia is the psychiatric term referring to the inability to experience pleasure in formerly enjoyable activities. Adolescents with anhedonia experience events, hobbies, interests, and people as less interesting or fun than they used to be. Adolescents express anhedonia by describing experiences as "boring", "stupid", or "uninteresting". They may withdraw from or lose interest in friends. If they are sexually active, they may have decreased libido or interest in sex (Lewinsohn et. al., 1998).

c) Change in appetite or weight

Change in appetite and corresponding weight loss or gain is characteristic of depression. However, appetite change may not be manifest as often in depressed youngsters as in depressed adults.

The failure to make expected weight gains satisfies this criterion for adolescents. Preoccupations with weight and body image are signs of anorexia nervosa.

Alternatively, some adolescents with depressive disorders crave and eat more specific foods and accordingly gain more weight than expected during their adolescent growth spurt (Flemming et al., 1990).

d) Sleep disturbance

Sleep disturbance is common in depressed adolescents, many of whom describe their sleep as nonrestorative and report difficulty getting out of bed in the morning. Sleep disturbance manifests as insomnia, hypersomnia, or significant shifts of sleep pattern over the diurnal cycle (Lewinsohn et.al., 1998).

- Initial insomnia- difficulty getting to sleep
- Middle insomnia- waking in the middle of the night
- Terminal insomnia- waking too early in the morning
- Hypersomnia- extended nighttime sleep or daytime napping
- Circadian reversal- daytime sleeping and nighttime arousal

e) Psychomotor agitation or retardation

Psychomotor retardation is common in depressed youth. Adolescents with psychomotor retardation talk or move more slowly than is typical for them. They produce less speech and present with longer response latencies. This criterion is met only if the adolescent actually appears to be moving in slow motion, the subjective experience of feeling slowed down does not qualify.

Alternatively, some depressed adolescents present with agitation: trouble sitting still, pacing, hand wringing, pulling at or rubbing clothes, tantrums, yelling, shouting, and non-stop talking (Brent et al., 1997). Adolescents can have alternating periods of retardation and agitation with a single episode of depression.

f) Fatigue or loss of energy

This criterion is met if the adolescent reports feeling chronically tired, exhausted, listless, and without energy or motivation. They may feel the need to rest during the day, experience heaviness in their limbs, or feel like it is hard to get going much of the time. Parent-adolescent conflict can result if the parents misinterpret the depressed adolescent's lack of energy and motivation as laziness, an oppositional attitude, or avoidance of responsibilities. Alternatively, parents may be concerned that the adolescent is medically ill and seek a medical explanation for the chronic fatigue (Flemming & Offord, 1990).

g) Feelings of worthlessness or guilt

The self-perceptions of depressed adolescents usually are marked by feelings of inadequacy, inferiority, failure, and worthlessness. Evaluation of this criterion is challenging because many teens do not directly acknowledge such as negative self-perceptions. They may manifest as:

- Reluctance to try to do things (fear of failure)
- Excessive self-critical assessment of accomplishments
- Difficulty identifying positive self attributes
- Desire to change several aspects of themselves
- An "I don't care" stance to avoid acknowledgement of insecurity
- Compulsive lying about success or skills to bolster self-esteem
- Envy or preoccupation with the success of others
- Marked self reproach or guilt for events that are not their fault
- Belief that they deserve to be punished for things that are not their fault.

Guilt about struggling with depression and its associated functional impairment is not considered sufficient to meet this criterion unless it is of delusional proportions (Brent et. al., 1997).

h) Impaired concentration, indecisiveness

Depressed adolescents usually have problems with attention and concentration that were not present to the same degree before the episode of depression. Their thinking and processing of information may be slowed. In addition, they are indecisiveness, which manifests as procrastination, helplessness, or paralysis in taking action. School performance may decline. Information from the school is necessary to evaluate this criterion because school performance typically is affected by the cognitive disturbance (Lewinsohn et. al., 1998).

i) Recurring thoughts of death or suicide

This criterion is met if the adolescent experiences recurrent thoughts of death (not just fear of death) or suicide, or attempts suicide. Morbid thoughts are common in depressed teens and manifest as:

- Thoughts that life is not worth living
- Thoughts that others would be better off if the adolescent were dead
- Preoccupation with music and literature that has morbid themes.

In a subset of depressed teens, morbid thoughts devolve to thoughts of suicide, suicide plans, and suicide attempts. Thoughts that contribute to suicidality include pervasive hopelessness (e.g. negative expectations for the future) and a view of suicide as an option to escape emotional pain (Steinberg, 2001). Adolescents with depression that includes psychotic features sometimes experience command hallucinations telling them to commit suicide.

2.2.3. History of Adolescent Depression

Historically, children were not considered candidates for depression (Weissman, Wolk & Goldstein, 1999). Mostly because of Freudian notions about the unconscious, depression had been viewed as a condition, which only affected adults. Today, childhood depression is widely recognized and health

professionals see depression as a serious condition effecting both adolescents and young children (Weissman et. al., 1999).

Views on adolescent depression have changed significantly even since the 1970's where childhood depression was thought to be masked by other conditions. The debate continues, even today, as to whether other childhood and adolescent behaviours are simply "masks" for childhood depression.

Mufson, Weissman & Moroeu, (1999), considers that in children, depression may often be mistaken for other conditions such as attention deficit disorder, aggressiveness, physical illness, sleep and eating disorders and hyperactivity. Although depression in children may be confused with attention Deficit Hyperactivity disorder, (ADHD), ADHD must begin before the age of 7. Other writers prefer to move past the philosophy of masked depression and view adolescent depressive symptoms as similar to those of adults (Weissman et. al., 1999).

2.2.4. The course of Depression.

The course and prognosis of mood disorder in children and adolescents depend on the age of on set, he severity of the episode, and the presence of comorbid disorders, a young age of onset and multiple disorders predict a poorer prognosis. The mean length of an episode of major depression in children and adolescents is about nine months; the cumulative probability of recurrence is 40 percent by two years. It has been reported that depressed children who live in families with high level of chronic conflicts are more likely to have relapses. Depressive disorders are associated with short term and long term peer relationship difficulties and complications, poor academic achievements, and persistent poor self esteem. The risk of suicide, which represents twelve percent of mortality in the adolescents age range, is significant among adolescents with depressive disorders (Kaplan & Sadock, 1998).

The course and prognosis of adolescent depression closely approximates that in the adult. Therefore, there is a great risk of chronicity and recurrence. As the average duration of a major depressive episode is in the order of nine to twelve months, this effectively means that one complete year may be impaired for the adolescent with Major Depression. As this is a crucial time for acquisition of academic, social and work skills, a depressive episode particularly if incompletely resolved, can significantly interfere with the normal development of the adolescent, which may have long-term vocational and psychosocial consequences.

2.2.4.1 Epidemiology

Mood disorders in preschool-age are extremely rare; the disorders increase with increasing age. About 2 percent have Major Depressive disorder among school-age children. Among adolescents, about 5 percent in the community have Major Depressive disorder. The rates of Major Depressive disorder are much higher among hospitalized children and adolescents than in the general community (Kaplan & Sadock, 1998). These attributes may exaggerate the effect of stressful life events and proneness to excessive worrying, which place them at risk for depression.

2.2.4.2 Gender and Depression

Before adolescence, equal numbers of boys and girls are depressed. By age 13, a dramatic shift occurs, and more than twice as many girls as boys are depressed, a proportion that persists into adulthood. This two-to-one ratio exists regardless of racial or ethnic background and has been reported in other countries (Lewinsohn et al, 1998).

Some studies suggest that the lower social status of females and the traditional upbringing of girls foster certain traits that may increase the vulnerability of adolescent girls to depression. Sex roles take on new importance, as

adolescents' bodies become more sex-differentiated. Emphasis on weight diverts girls from developing their own interests, talents and internal character to obsessing over their appearance. During adolescence, the self-esteem of many formerly self-confident and assertive girls gradually becomes eroded. Self-esteem in girls' peaks at the age of nine, then, for some, begins to plummet (Wells et. al., 1985).

In addition to low self-esteem, some adolescent girls develop certain characteristics: pessimistic thinking, a sense of having little control over life interfere with taking action to cope with them.

It has also been hypothesized that higher depression rates among girls occur when they start to interact with boys more frequently. Fearing that competition with boys may interfere with their relationships, some girls are likely to minimize their capabilities. These attitudes are subtly encouraged by society and reinforced by the media.

Family factors are related to depression in girls. Research indicates that girls are more likely than boys to react to negative events in the family. Girls learn about being female from modeling themselves on their mothers (Masche & Barber, 2001). Female development throughout the lifespan, according to self-in-relation theorists, is based on the importance of attachment and relationships. Some experts think that females' tendency to place greater value than males do on interpersonal connection and relationships with other people renders them more vulnerable to losses and depression.

According to cognitive theories of depression, how individuals view and interpret stressful events affects whether or not they become depressed (Flemming & Offord, 1990). An adolescent who feels helpless sees problems as insurmountable. However, the helpless pattern results in depression only for

some. The explanatory style is an important factor that determines the person's feelings.

Girls and boys typically have different styles of explaining their experiences to themselves. At a young age, boys tend to have a more negative explanatory style than girls, then in the upper elementary grades, more girls than boys show a helpless cognitive style (Wells et. al., 1985).

Coping strategies make a difference in whether or not a person becomes depressed when stressed. During early adolescence, as boys and girls develop different explanatory styles, they also develop different styles of coping in stressful situations. Research has shown rumination is one of the risk factors associated with higher rates of depression among adolescent girls. Boys, in contrast, use more problem solving and distraction techniques. A number of studies show that individuals who ruminate when distressed show longer and more severe periods of depression symptoms and are more likely to develop a depressive disorder (Shiner & Marmorstein, 1998).

2.2.5. Clinical Symptoms of Depression:

2.2.5.1. Affective symptoms:

Depressed mood is the most striking symptom of depression. Depressive's adolescents experience feelings of sadness, dejection, and an excessive and prolonged mourning. Feelings of worthlessness and having lost the joy of living are common. Wild weeping may occur as a general reaction to frustration or anger. Such crying spells do not seem to be directly correlated with a specific situation (Steinberg, 2001).

2.2.5.2. Cognitive Symptoms:

Besides general feelings of futility, emptiness and hopelessness, certain thoughts and ideas are clearly related to depressive reactions. For example, the person

feels a profound pessimism about the future. Disinterest, decrease energy, and loss of motivation make it difficult for a depressed adolescent to cope with every day situations. School and work responsibilities become monumental tusks, and the adolescent avoid them. Self-accusation of incompetence and general self-denigration are common, as are thoughts of suicide. Other symptoms include difficulty in concentrating and in making decisions. Depression maybe considered to be reflected in a cognitive triad, which consist of negative use of the self, of the outside world, and of future world (Beck, 1966). The adolescent has pessimistic beliefs about what he or she can do, about what others can do to help, and about his or her prospects for the future.

2.2.5.3. Behavioural Symptoms:

The appearance and outward demeanor of a person is often a telltale sign of depression. The person clothing may be sloppy or dirty, hair may be uncapped and personal cleanliness neglected. A dull, masklike facial may become characteristic. The depressed adolescent moves his or her body slowly and does not initiate new activities. Speech is reduced and slow, and the person may respond with short phrases. This slowing down of bodily movements, expressive gestures, and spontaneous responses is called psychomotor retardation (Hammen, et al., 1996). The adolescent often shows social withdrawal and lowered work and school productivity. By contrast to this typical retarded condition of depressives, however, some may manifest and agitated state and symptoms of restlessness.

2.2.5.4. Physiological Symptoms:

Depressed adolescent often experience a loss of appetite and weight, although some may actually have increased appetite and gain weight. The loss of appetite often stems from the person disinterest in eating whereby food seems tasteless. Depressives may become constipated and not have bowel movements for days at a time (McClellan & Werry, 1997).

Sleep disturbance is a common complaint. Difficulty in falling asleep, waking up early, waking up erratically during the night, insomnia, and nightmares leave the depressive exhausted and tired during the day. Many depressives dread the arrival of night because it represents a major fatigue-producing battle to feel asleep.

In women, depression may disrupt the normal menstrual cycle. Usually, the cycle is prolonged, with possible skipping of one or several periods. The volume of menstrual flow may decrease. Many depressives report an aversion to sexual activity. Their sexual arousal dramatically declines (Lewinsohn, et al., 1998).

2.2.6. Causes of Depression

The precise causes of depression are not known. Extensive research on adults with depression generally points to both biological and psychological factors (Klerman & Weissmans, 1989). However, there has been substantially less research on the causes of depression in children and adolescents. Over the years, a number of different explanations have been proposed to account for depression. Some of the major theories are discussed below.

2.2.6.1. Sociocultural explanations

Cross-cultural studies of mood disorders have found that prevalence rates and manifestation of symptoms vary considerably among different cultural groups and societies (Shiner, et al., 1998). The expression of symptoms for a particular disorder may differ from culture to culture (Birmaher, et al., 1998). These findings suggest that factors such as culture, social experiences, and psychosocial stressors play an important role in mood disorders.

a) Stress and depression:

- Conceptualizations of the role of stress in psychopathology in general and depression in particular have typically proposed that stress is one of three broad factors that are important to consider: diathesis, stress and social supports. Diathesis refers to the fact that because of genetic or social conditions, certain individuals may have a predisposition or vulnerability to developing depression (Hammen, et al., 1985). Stress may act as trigger to activate this predisposition, especially when individuals lack resources to adjust to stress. The importance of stress in depression has been demonstrated. Studies have increasingly shown that severe psychosocial stress often precedes the onset of major depression (Brown, et al., 1999). The investigators found that chronic stress was more highly related to depression than was acute stress. Therefore, vulnerability may arise from early experiences in the family.

b) Social support:

- Other investigators have examined social supports as buffers against depression. The assumption is that persons who are exposed to stress may or may not develop depression, depending on whether they have adequate social supports. Harrington et al., (1996) studied the role of social resources on stress and depression. Information included personality characteristics, family supports, stress and depression. Persons with positive personality traits and family support, compared to those with the same characteristics, had less depression four years later, even when initial depression level was controlled. The researcher speculated that personal or family resources help individuals cope and adjust to stress.

2.2.6.2. Psychoanalytic explanations

The psychoanalytic explanation of depression focuses mainly on two concepts: separation and anger. Separation may occur when a significant other person dies or leaves for one reason or another. This separation can either be physical or symbolic. For example, the withdrawal of affection or a rejection can induce depression. Kaplan & Sadock (1998) believed that depressives are excessively dependent people because they are fixated in the oral stage. He viewed the mouth as primary mechanism by which infants relate to world, so being fixated at this stage fosters dependency. Being passive and having others feels one's needs results in emotional dependency that continues into adult life. Thus, for people fixated in the oral stage, self-esteem depends on other important people in the environment.

When a significant loss occurs, the mourner's self esteem plummets. In addition, the mourner is flooded with two strong sets of feelings, anger and guilt. The anger, which arises from the sense of being deserted, can be very strong. Because depression cannot always be correlated with the immediate loss of loved one, Freud used the construct of "symbolic loss" to account for depression that did not result directly from loss (Hooley, Orley & Teasdale, 1986). That is to say, any form of rejection or reproach may be perceived by the depressive as symbolic of an earlier loss. Psychoanalysis has strongly emphasized the dynamics of anger in explaining depression. Many depressed patients have strong hostile or angry feelings. Such a belief has let some to speculate that depression is really anger turned against the self. Freud suggested that, when a person experiences a loss, he or she might harbour feelings of resentment and hostility toward the lost person in addition to feelings of love and affection (Lewinsohn, et al., 1998).

Psychoanalytic theories of adult depression attribute the low self-esteem, hopelessness, unhappiness, and other symptoms of the disorder to situations involving loss. A person, who experiences the loss of a loved object, may feel anger at being abandoned or at having some issues unresolved. This anger,

however, is threatening, since it is directed at the one who is loved and lost. To repress the feelings of anxiety and shame related to having this anger, the person represses the anger or unconsciously turns it on the self. This "anger turned inward" is then manifest on the surface in the form of negative cognitions, low self-esteem, hopelessness, guilt, and unhappiness (Hooley, et al., 1986).

Depression in very young children may be seen as the loss of the attachment object, creating a void in the development of the self through object relations and identification. Other analytic concepts such as repressed desires, unsatisfied need to be the center of the mother's attention, and frustrated desire for narcissistic gratification have also been invoked to explain the development of depression in children (Robinson , Berman & Niemeyer, 1990).

2.2.6.3. Learning explanations:

Behaviourists also see the separation or loss of a significant as important in depression. However, behaviourists turn to see the cost as reduced reinforcement rather than as the untestable concept of fixation or symbolic grief. When a loved one is lost, an accustomed level of reinforcement is immediately withdrawn. No longer can one obtain the support or encouragement of the lost person. When this happens, one's level of activity is markedly diminished because an important source of reinforcement has disappeared. Thus, many behaviourists view depression as a product of inadequate or insufficient reinforcers in a person's life, leading to a reduced frequency of behaviour that previously was positively reinforced (Roberts & Bengtson, 1993).

As a period of reduced activity continues, the person labels himself or herself depressed. If the new lower level of activity causes others to show sympathy, the depressed person may remain inactive and chronically depressed. The depression tends to deepen, and the person disengages still further from the environment and further reduces the chance of obtaining positive reinforcement

from normal activity. The result may be continually deepening and depression. Depression has been associated both with low level of self-reinforcement and with reduction in environmental reinforcements (Gotlib, et al., 1998). In other words, when people get less reinforcement from the environment and do not give themselves reinforcement, they are prone to become depressed. Depressives may lack skills required to replaced lost environmental reinforcements.

Along with reinforcement view of depression, Lewinsohn, et al. (1998) suggested three sets of variables that may enhance or hinder a person's access to positive reinforcement. First, the number of events and activities that are potentially reinforcing to the person is important. This number depends very much on individual differences and varies with the biological traits and experiential history of the person. For example age, gender, or physical attributes may determine the availability of reinforcers. Young people are likely to have more social interaction than retired. Second, the availability of reinforcements in the environment can also affect the person. Hash environment such as remote isolated places reduce reinforcement. Third, the instrumental behaviour of the person, the number of social skills that can be exercised to bring about reinforcement, is important.

Depressed patients lack social behaviour that can elicit positive reinforcements (Lewinsohn, et al., 1998). They interact with fever people, respond less and have very few positive reactions, and initiate less conversation. Depressed also feel more uncomfortable in social situations and they illicit depression in others (Hammen & Rudolph, 1996). Further, depressed people seem to be preoccupied with themselves; they turn to talk about themselves without being asked to do so. Depressives may even create conditions that further their depression or drive others away and thus loose any social reinforcements that others could provide (Carnelley, et al., 1994). A low rate of positive reinforcement in any of these three situations can lead to depression.

Lewinsohn also recognized the important role of other factors of depression. Although a low rate of positive reinforcement is a critical feature of his theory, Lewinsohn and colleagues (1998) adopted amore comprehensive view of depression. They believe that an antecedent event such as stress disrupts the predictable and well-established behaviour patterns of people's lives. Such disruptions then reduce the rate of positive reinforcements or increase aversive experiences. If individuals are unable to reverse the impact of stress, they begin to have a heightened state if self-awareness and to experience depressed affect. With depressed moods, persons then have a more a difficult time functioning appropriately, which makes them further vulnerable to depression.

2.2.6.4. Cognitive Explanations:

Some psychologists believe that a low self-esteem is a key to depressive reactions. All of us have both negative and positive feelings about what we see as our "self". Some People especially those who are depressed, have a generally negative self-concept. Such people perceive themselves as unworthy and incompetent, regardless of reality. If they do not succeed as anything, they are likely to dismiss as pure luck or to forecast eventual failure. Hence a cognitive interpretation of ones self as unworthy may be lead to a host of thinking patterns that reflects self blame, self-criticism, and exaggerated ideas of duty and responsibility (Hodgman, 1985).

a) Beck's Cognitive theory of Depression

One major cognitive theory has been advanced by Beck (1961). According to his theory, depression is a primary disturbance in thinking rather than basic disturbance in mood. How persons structure and interpret their experiences determines their affective states. If individuals see a situation as unpleasant, they feel an unpleasant mood. Depressed persons are said have schemas that set

them up for depression. A schema is a pattern of thinking a cognitive set that determines a person's reaction and responses.

According to Beck's theory, depressive operate from a "primary triad" of negative self-use, present experiences and the future. Four errors in logic typify that this negative schema, which leads to depression is characteristics of depressives. Arbitrary inferences that is, the depressive tends to draw conclusions that are not supported by evidence. These draw erroneous conclusions from their available evidence. The second error is selected abstraction. The depressive take a minor incident or detail out of context and the incidents on which the depressive focuses tend to be trivial. Over generalization is the third error. A depressive tend to draw a sweeping conclusion about his or her ability performance or worth from one single experience or incident (Steinberg, 2001).

The fourth error is magnification and minimization. The depressive tends to exaggerate limitation and difficulties and minimize accomplishments, achievements and capabilities. Asked to evaluate personal strength and weaknesses, the depressed person lists many shortcomings but finds it almost impossible to name any achievements. All four of this cognitive processes can be seen as results or causes of low self-esteem, which makes the person expect failure and engage in self-criticism that is unrelated to reality. People with low self-esteem may have experience much disapproval in the past from significant others such as parent and other family members. Their parents or significant others may have responded to them by punishing failures and not rewarding success or by holding unrealistically high expectations of standards (Hofer et al., 1998).

Beck's approach is summarized as follows: The first principle of cognitive theory is that all your moods are created by your cognitions. Moods are caused by a particular type of cognition, self-comparisons, in conjunction with such general attitudes as feelings of helpless. The second principle is that when a person feels

depressed their thoughts are dominated by a pervasive negativity (Hofer et. al., 1998). The third principle is that the negative thoughts nearly always contain gross distortions.

a) i. Negative views

Beck's cognitive theory states that somewhere in childhood the depressed-to-be person develops a negative view of the self, the world, and the future: "I'm no good", and "it won't work out." Each of these negative views gets expanded into detailed beliefs: " I'm dumb", "I'm ugly too" and on and on. These negative assumptions seem to be held on a very primitive level, facts don't influence these beliefs, so they never get questioned or tested against reality. These negative views just lie doormat even while more rational evaluations of self; world, and future may also be developed and used as we mature into adults (Beck, 1961). Then later in life, when the self is hit with some serious loss or stress, often one that reminds us of a loss or trauma at an early age, the old unreasonable and destructive negative ideas suddenly take over and dominant our thinking. It is our negative ideas that produce our depression, not the stressful triggering event that produces our depression. The deeper the depression, the more the negative ideas replace rational thinking (Hooley et al., 1986).

Under the influence of this primitive, negative thinking, our logic fails us. For example, we jump to conclusions, look at only one detail and disregard the big picture, overgeneralize from one experience, magnify our faults and minimize our achievements, and take the blame. All of this adds a very dark and gloomy shadow over our mental life.

Research has confirmed that sad-prone people notice the negative aspects of an event and assume too much of the responsibility when things go wrong. It has also been experimentally demonstrated that thoughts can influence feelings and behaviour (Klerman & Weissmans, 1989). Therefore, it isn't just the depressing event that makes us sad but also every time we remember and fantasize about

the disappointing event in the past or imagine a similar thing happening in the future, more and more depressive mood is created. Although negative cognition clearly accompanies depression, it has not been proven that negative thinking is the exclusive cause of depression; other factors may be involved in causing depression.

Some studies have demonstrated a relationship between cognition and depression. The investigated concluded hat although two individuals may have equal level of depression, the one who has negative self-cognition may turn out to have more serious and longer lasting depressive episode. Further more, depression is related to memory bias. When depressed individuals are given list of words that vary in emotional content, they turn to recall negative words in contrast to non-depressive. This may indicate a tendency to attend to and remember, negative and depressive events (Ryan et al., 1987).

b) Stress and coping theories

In addition to cognitive theories, another second group of etiological theories of depression emphasizes stress, coping, and social support. These theories hold that stress renders individuals vulnerable to negative interpretations and emotions regarding themselves and their environment. If individuals feel overwhelmed by stress, they may become unhappy, hopeless, and desperate, resulting in the development of depressive symptoms. Factors that buffer individuals from stress, such as adaptive coping and social support, attenuate the effects of the stress and reduce risk of depression (Husain, 1990).

Stress, coping and social support within the family may be especially important in the etiology of depression. Family stresses can contribute to the development of depressive symptoms, and the family can be a source of support to buffer its members from the negative effects of stress (Kalsow, et al., 1994). These effects may be particularly pronounced for children, who are emotionally and physically

dependent on the family. Furthermore, modeling of affective responses to situations and of coping behaviours can have a profound effect on child behaviour.

Depressed children perceive their family more negatively than do nondepressed children, and depressed children are likely to have families with more psychopathology (Husain, 1990). The timing of child depression is closely related to the manifestation of maternal depression. It appears that high stress and the presence of a maternal model of depression put children at substantially greater risk than stress alone. Once the depression emerges in the family system, it may be perpetuated by the system as a way of deflecting future stresses on the family.

2.3. The Role of the Family

All humans are born into this complex world in such a helpless state, that if adults do not immediately take charge of them, meet their daily needs and protect them, they would not survive. The style of behaviour gradually and uniquely developed in the socialization process, referred to as personality development (Monroe, et al., 1999).

Family is a social institution that represent in all cultures, although the organization of the family can be different in certain principles concerning its composition. The family plays an important role in the development of the child. The child need "good enough" environment to grow and develop well. Many personality theorists have written about the significance of the family influence to the development and growth of the child. These theorists study the family because is a social institution which is present.

a) The parent-adolescent relationship

The ability to reason from the possible to the real could influence the parent-adolescent relationship in the following ways:

- Adolescents are often confronted with several alternatives or possible solutions to a problem. Although it is difficult for them to decide which alternative or solution is the correct one, they still want to make their own decisions without the help and guidance of their increasing drive towards autonomy. This could lead to conflict if the parents do not take into consideration their adolescent children's drive towards autonomy and allow them to make their own decisions (Shiner & Marmorstein, 1998).
- Because of the questioning attitude of the adolescents, they require that their parents explain to them their reasons for what they expect from them. If parents do not accept that adolescents have their own views, there could be conflict between the parents and their adolescent children (Shiner & Marmorstein, 1998). This questioning attitude could also lead to adolescents' questioning the values or behaviors of their parents.

Abstract reasoning also plays a role in the parent-adolescent relationship. Piaget (1970) was of the opinion that the adolescents' questioning of the behavior and authority of their parents, and their idealistic concern about how things should be are the results of their abstract reasoning ability.

2.3.1. Winnicott's conception of the family

The family is so important to each and everyone. The family has its own growth and the individual experiences and the changes that belong to the family's gradual expansion and to its troubles. They give protection to the child not to contact with the world but because of the fact that most families are extended the child becomes exposed to the outside world (Kleirman & Weissmans, 1989). The existence of the family and the maintenance of the family atmosphere result from the relationship between the parents in a social setting in which they live.

The relationship of the family depends entirely on the wider circle around them. The pressure from the society disrupts the family. The child listens to peer pressure. The families serve as the protection of the child and also give normal, emotional and financial support to the child. The family continues to be important all the time and accounts for much of the traveling. The family protects the child from the world (Joiner & Metalsky, 1995).

2.3.2. Horney's conception of the family.

Horney believed that the social relationship between the child and the parents plays crucial role in personality development. By this it meant, that the child needs security and freedom from fear. Childhood, according to Horney is dominated by the need for safety. The child's security is therefore determined and influenced by the treatment he or she receives by their parents (Brown et. al., 1993). If parents underline the child's sense of security it could result in feelings of hostility. These feelings of repressed hostility could lead to a sense of helplessness, fear of parents and guilt feelings.

Horney attributes the child's feeling of guilt to the fact that parents make the children feel guilty about being hostile and rebellious. Horney states, "the more guilt the child feels, the more deeply repressed will be the hostility" (Shiner & Marmorstein, 1998). If the childhood need for safety is undermined condition of basic anxiety develops.

Horney further postulates that a child can stand a great deal of what often is regarded as traumatic for any child, namely, sudden weaning, occasional beating, as long as inwardly the child is loved. The sense of such a negative atmosphere along with what body explains as an atmosphere rife with other frightening elements such as battles between parents, injustice and need for affection, disappointment, developments of unspoken competitiveness, inhibition

attempts to get affection on the basis of weaknesses, helplessness or suffering (Steinberg, 2001).

Other harmful contribution towards a negative atmosphere could include ridiculing a child independent thinking, spoiling a child interest in it's own pursuit, and disturbing is or her friendships. All of these constitute an attitude of the parents, whether exercised internationally or not in effect means breaking the child's will (Wells et al., 1999). It must be kept in mind that we live in a highly competitive world that is individualistic, even in culture. Further more, the competition becomes effective in the family and can be illustrated between siblings, at school on social relations and finally in love life. An individual attempts to overshadow another individual through competition to achieve a desired goal.

2.3.3. Fromm's conception of the family.

Fromm did not elaborate extensively on the concept of the family development. If one has to assume that early experiences might include childhood within the family, as other influences outside the family can it be concluded that a family has a minor role to play in human development. Fromm described individual development as a social function of education. The family is only part of an educational process that prepares a child in order to function normally in the society out there. He regards the family as a psychological agent of society, for transmitting societal values and norms into the child. The parents then shape the child personality by representing society through their own personality (Harrington et al., 1996).

Fromm believed that the mother-child relationship is the most fundamental relationship in fulfilling the basic needs from an early age. Bonding with the mother, within a healthy family fulfill the child's need. For relatedness while also

contributing on independence in late life. A healthy family should be able to provide with what Fromm termed mature love in his need for relatedness and the bonding with it's mother in the need for rootedness. A healthy family constitutes relationship of love, where being owned by the other, but to be loved and able to grow and develop does not impair every member of the family's development and creativity (Hooley et al., 1986).

The mere fact that human need a sense of relatedness and rootedness make them dependent on significant others. One has to consider that the family does not only consist of the parents and only one child. Other family members also have a significant role to play in development and the bond between siblings also has a strong effect on the child's development (Brown et. al., 1993). The role of the family whether is good or not is determined by the character of the person.

2.3.4. Erikson's conception of the family.

Identity versus confusion is the fifth stage of personality development. It occurs during adolescence. Individuals who have adequately resolved the conflicts in prior stages enter adolescence with a growing sense of identity. Their parents see them as the trust worth and are trusted in return (Papalia & Olds, 1992).

The parents have given the child a name and have to react with love and consistency. During this stage young people have to see themselves as an integral part of their families. Identity involves integration by the ego of all the previous identifications learned by a child as participant in a variety of groups (family, church, school). Erikson sees a large part of our identity as dependent upon what we do for a living, the support we receive form our families and our internalization of the ideals of our culture (Puig-Antich et al., 1985).

2.3.5. Adler's conception of the family.

As an indivisible whole, a system, the human being is also a part of larger wholes or systems, the family, the community, all of humanity, our planet. In these contexts, we meet the three important life tasks: occupation, love and sex, and our relationship with other people, all social challenges. Each human being has the capacity for learning to live in harmony with society. This is an innate potential for social connectedness, which has to be consciously developed (Joiner & Metalsky, 1995).

Before making any judgment about a human being, we must know the situation and environment in which he or she grew up. The child, on entering the world, experiences himself as the weakest thing in his surrounding. Thus, family plays a vital role in human development. According to Adler (1957), family constellation refers to the sociological facts of the family as hey affect each member, parents are the most influential member of the family (Monroe et al., 1999).

According to Adler, the first major social situation that the child encounters is in relation to the mother. In fact, it is the nature of the mother's early interactions with her child that primarily determine whether or not the child will have a healthy, open attitude towards other people (Hammen, 1991). Even though each person is born with the potential for social interest, a mother needs to instill it in her child. For example a child who did not experience love and care from his or her mother would unlikely project it to others or live harmoniously with others. The mother should the child's trust before spreading his or her interest towards other members of the family.

Siblings are also important in human development. The mother should spread the child's interest towards other children of the family before transferring it to the society. Children should respect each other in spite of the position he or she occupies. Although the first-born possess power and some authority, young

children should be respected. Gender difference should not bring conflicts between siblings. If a child can fulfills his or her social interest adequately, he or she will be able to co-operate with people at school and work well (Steinberg, 2001).

Adler must be credited as the first theorist to include not only a child's mother and father and other adults as early influence on the child, but the child's brothers and sisters as well. His consideration of the effects of sibling and the order in which they were born is probably what Adler is best known for. Birth order is one way to gain an understanding of friends and family members. Birth order helps determine a person's expectations and strategies for dealing with people and their weaknesses.

The only child is more likely than others to be pampered. After all the parents are more likely to take special care, sometimes anxiety-filled care of their pride and joy. If the parents are abusive on the other hand, the only child will have to bear that abuse alone.

The first child begins life as the only child with all the attention to him or herself. Some become disobedient and rebellious and other withdrawn when the second child arrives. Adler believes that first children are more likely than others to become problem children. They tend to be relatively solitary and more conservative than the other children in the family.

The second child has the first child as a sort of pace-setter, and tends to become quite competitive, constantly trying to surpass the older child and they often succeed (Adler, 1957). Many feel as if the race is never done, they tend to dream of constant running without getting anywhere.

The youngest child is likely to be the most pampered in a family with more than one child. And so youngest children are the second most likely source of problem

children, just behind first children. On the other hand the youngest may also feel incredibly inferiority, with everyone older and therefore superior.

Adler only made mentioned of the nuclear family from the Western context. Nuclear family consists of the father, mother, and children. Thus, Alder does not accommodate most of South Africa families. In South Africa, the extended family is popular. It includes grandparents, parents or single parent, aunts, uncles and children. All members of this extended family are also influential in human development. For example, most children grow up with grandparents because parents are working far away form home.

Summary

The changes and demands of adolescence can be challenging. As teens grow older they lives become more complex, and they are more likely to feel anxious and depressed by events in their lives. For some youth feelings of depression are intense and long-lasting. For these youth, depression interferes with life and can lead to serious problems if untreated.

Depression is one of the most common psychiatric disorders in the general population, and depression in adolescents is of particular concern because of its wide-ranging effects on adolescent health. It is an illness that has a profound impact on family members who live with the person as well as love the person. Depression is an illness, which can often afflict numerous people in a family system. The way in which family functions and the roles assigned to its individual members play an important part in their determination of the different members' personality characteristics. Therefore more psychopathological behaviours are attributed to family interaction systems. Thus, when adolescents feel their family members are supportive and provide clear, consistent discipline brings lower levels of depression.

CHAPTER 3
RESEARCH METHODOLOGY

3.1. RESEARCH METHODOLOGY

A survey design was utilized in the present study. Data was collected directly from the subjects. A questionnaire was used to collecting subjects' attitudes and perception. Fink and Kosecoff (1998) define a survey as a "method of collecting information directly from people about their ideas, feelings, health, plans, beliefs, and social, educational and financial background." Therefore, all surveys rely directly on asking people questions to elicit information.

Nachmias and Nachmias (2000) describe a survey as " a method of collecting data in which a specifically defined group of individuals are asked to answer a number of identical questions". In fact, survey research is useful in describing the characteristics of a large population, making large samples feasible and flexible. Through a survey design it is possible not only to describe population parameters but also to predict relationships between those characteristics. The researcher can reach a large number of respondents with relatively minimal expenditure. A single instrument can measure numerous variables and statistical manipulation during the data analytic phase can permit multiple uses of the data set (Babbie, 1998).

Fowler (1984) saw the purpose of a survey being to produce statistics, which is a quantitative or numerical description of some aspects of the sampled population. People answer questions asked and their answers constitute the data to be analyzed. Information is collected only from a fraction of the population that is from a sample rather than from every member of the population. The survey has a considerable degree of representative with careful pre-testing of the instrument and with the use of random sampling techniques. Surveys using a questionnaire

are likely to cover a wide geographical area, to reach many people, to ensure respondents' anonymity and require fewer skills to administer (Fowler, 1995).

Babbie (1998) saw the survey method as giving the researcher a quantitative method of establishing relationships and of making generalizations about known populations. The survey is able to do this because of its standardize data collection procedures, which involves a systematically selected sample of individuals who are exposed to a fixed set of questions.

Descriptive method was used to attempt to describe phenomena, as they exist. Fowler (1984) indicates that descriptive method reveals individual psychological dynamics and provides data to build hypothesis.

3.2. Quantitative Design

Quantitative design was used in this study. Quantitative design is defined as " one that is concerned with measurement, measuring the magnitude, size of extent of a phenomenon " (Nachmias and Nachmias, 2000). It counts, measures and analyses data statistically. Quantification is primarily oriented toward a cumulative tradition of gaining empirically based scientific knowledge. Therefore, quantifiers are able to interrelate measurements in order to elicit predictions and explanations from what they have studied.

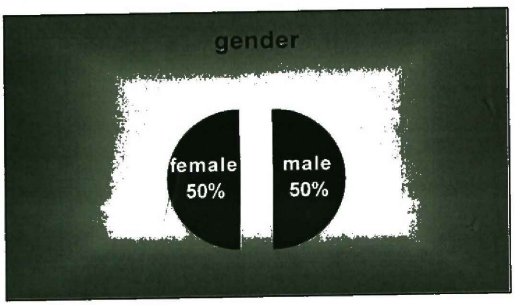
3.3. Sample

Adolescents suffering from Major Depressive Disorder at the adolescent unit of Weskoppies Hospital completed the questionnaire.

3.3.1. Sample description

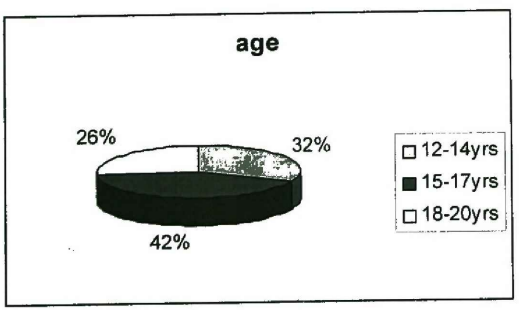
There were 25 male and 24 female participants. The graph below displays the sex of the respondents who participated in the study.

Figure 1: Distribution of the sample according to gender



Respondents were represented in three different age groups. There were 32% respondents between 12-14 years, 42% respondents between 15-17 years and the last group of between 18-20 years had 26% of respondents. The graph below displays the age of the respondents.

Figure 2: Distribution of the sample according to age



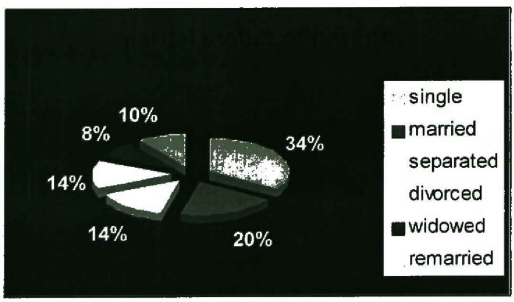
Respondents were also grouped according to their education level. The table below displays the education level of the respondents.

Table 1: Distribution of sample by level of education

Level of education	Frequency	%
Grade 1-std 5	27	54
Std 6-std 9	15	30
Std 9 – std 10	8	16
Total	50	100

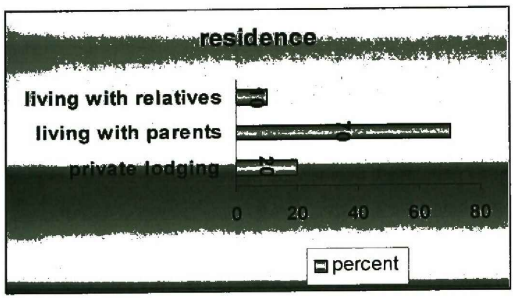
Marital status of parents was also a variable in which respondents were grouped. It is displayed in the graph below.

Figure 3: distribution of sample according to marital status of parents



Respondents were grouped according to their residence. The graph below illustrates the group clearly.

Figure 4: Distribution of sample according to residence



3.4. Procedure

Adolescents suffering from Major Depressive Disorder were identified using their diagnosis. The chosen groups were contacted and the researcher was introduced to them. The aims and objectives of the study were explained to them. Participants were informed that participation was anonymous and confidential as no identifying information was used in the questionnaire. The respondents were also informed that they were under no obligation to participate. Then, verbal permission was requested for participation. Participants were then given time to browse the questions and ask questions where necessary.

3.5. Research Instrument

The questionnaire is an instrument that could be used to observe beyond the physical reach. Polansky (1986) defines a questionnaire as a common research instrument that comprises a series of questions that are filled by all participants in a given sample. Therefore, a questionnaire was used in this study.

The questionnaire consists of three parts. The first part comprises of biographical data, which includes gender, age, level of education, marital status of parents

and adolescents' relationship with their family. The second part comprises questions from the Differential Loneliness Scale.

3.5.1. Differential loneliness scale

The questionnaire was adapted from the Differential loneliness scale (DLS). The DLS asks respondents to evaluate the quality and quantity of their interactions. It is a 60-item scale. Among these 60 items, 22 concerned friendship, 18 concerned family relationships, 12 concerned romantic-sexual relationships, and 8 concerned relationships with groups. 18 items concerned family relationship was adapted since the study is only concerned with the quality and quantity of family interaction. Each item is answered 'true' or 'false'.

3.5.1.1. Reliability of Differential loneliness scale

The K-R 20 internal consistency coefficient for the initial nonstudent adult sample was .92. For the subsequent studies of nonstudent adults, K-R 20 was .89 for men and .92 for women. For this same group, the reliabilities of the subscales were as follows: Romantic-Sexual, .71,Family,.70, Friends,.72,Groups,.73.

3.5.1.2. Validity of Differential loneliness scale

a) Convergent

In the nonstudent groups studied with the 60-item scale a single-item loneliness question was asked: "How lonely would you say you are, generally?" Subjects replied on a 10-point scale ranging from "never" (1) to "all the time" (10). This variable was correlated with the DLS score, and the following results were obtained: for men (under 25 years), r=.45, for older men,.58, for younger women,.55, for older women,.45.(All r values were significant at $p<.001$.). The

four subscales correlate .39 with each other, on the average, which is considerably below their reliabilities (averaging around .72). This suggests that the subscales do measure somewhat different content areas as designed.

b) Divergent

The items were selected to minimize correlations with the social desirability scale of Jackson's (1967) PRF, the depression scale of Jackson and Messick's (1971) DPI, and the anxiety and self-esteem scales of Jackson's (1976) JPI. Even so, the correlation with social desirability was 0.59 with self-esteem, 0.40 with anxiety, 0.42, and 0.62 with depression (all highly significant). This suggests that this cluster of variables cannot be fully disentangled.

3.5.2. Beck Depression Inventory

The third part consisted of Beck Depression Inventory (BDI). The Beck Depression Instrument was designed to assess the intensity of depression in terms of 21 symptom-attitude categories. The BDI is a self-report rating inventory measuring characteristic attitudes and symptoms of depression (Beck et al, 1961).

3.5.2.1. Reliability of BDI

a) Internal Consistency

In his 1967 book, Beck reported an odd-even split-half reliability coefficient of .86.

b) Test-Retest

According to Steel et al. (1986), stability coefficients are usually in the .70s over a period of weeks. If the respondent is asked to describe himself or herself for just today, then the BDI is evaluating state depression, which would not be expected to display much stability. If the patient describes himself or herself for at least the past week, however, then the BDI is assumed to be measuring trait depression.

3.5.2.2. Validity of BDI

a) Convergent

The BDI is consistently and significantly related to clinical ratings of depression. The magnitude of the correlations ranges from .60 to .90, with a variety of sample sizes. BDI
Scores are also reasonably and significantly related to biological, electrophysiological, psychosocial, and cross-cultural manifestations and correlates of depression, and with observationally documented sleep disturbances.

b) Discriminant

In his 1967 book, Beck reported several pieces of evidence for the BDI's disciminant validity: for example, a higher correlation with clinical ratings of depression (.59) than with clinical ratings of anxiety (.14)

3.5.3. Family Functioning in Adolescence Questionnaire (FFAQ)

3.5.3.1. Scale description

The 42-items of the Family Functioning in Adolescence Questionnaire (FFAQ) yield six separate dimensions, each of which is related to one or more developmental tasks to be mastered during the adolescent stage of life. 21-items were adapted from the FFAQ. The purpose of the FFAQ is to assess the psychosocial functioning of a family, as perceived by the adolescent.

3.5.3.2. Reliability

The internal consistency is indicated by Kuder-Richardson Formula 8. Reliability coefficients higher than 0.88 for the total score were obtained in all the subsamples. All the scales also obtained reliability coefficients higher than 0.60 for all the subsamples. Correlations between scales were expected to be moderate to high.

The correlations between scales range from 0.37 (between structure and external systems) to 0.73 (between affect and communication).

3.5.3.3. Content validity

To ensure that the FFAQ would be accepted to all cultures in South Africa, the application of the instrument was from the outset a team effort with representatives from Asian, African and Western cultures. Practical explanation of FFAQ items were formulated by the research team to ensure that the items will be clearly understood by younger adolescents as well as people from all the cultural groups. It was handed to all administrators for use when respondent

might find difficulty in understanding any specific item. By doing so, a standardized practical explanation was given to any inquiry. It was found that it was only used in exceptional circumstances, as the items were usually clearly understood by subjects.

CHAPTER 4
RESULTS

4.1. DATA ANALYSES

Depressed people tend to have less social support. Therefore, the support and involvement of family plays a crucial role in helping someone who is depressed.

Table 2: Descriptive statistics of the sample

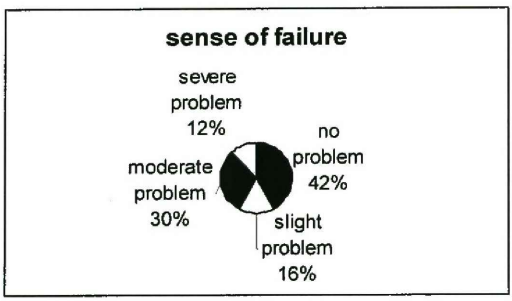
Variable	*Mean*	*Std. Deviation*	*Variance*	*Minimum*	*Maximum*	*Range*
Failure	2.02	1.10	1.204	1	4	3
Famopen	1.53	.50	.255	1	2	1
Famsupp	1.27	.45	.200	1	2	1
Famtalk	1.47	.50	.255	1	2	1
Famunder	1.29	.46	.210	1	2	1
Fatigue	2.29	1.08	1.165	1	4	3
Suicide	1.84	.82	.668	1	3	2
Sympathy	3.26	1.27	1.625	1	5	4
Feelings	3.36	1.44	2.072	1	5	4
Together	3.38	1.21	1.465	1	5	4
Care	3.32	1.54	2.385	1	5	4
Guilt	2.11	1.09	1.192	1	4	3
Quality	1.44	.50	.253	1	2	1

The failure (sense of failure), fatigue (fatigability), suicide and guilt are variables that describe the symptoms of depression. The severity of the variables indicates the severity of the depression. The social support aspects is indicated by the following variables: famopen (I am not very open with members of my family), famsupp (Some of my family will stand by me in almost any difficulty), famtalk (I spend some time talking individually with each member of my family), famunder

(I don't think that anyone in my family really understand me), famrel (I have a good relationship with most members of my immediate family) and quality (generally I feel that members of my family acknowledge my strength and positive qualities.

The following statements indicate family relationship: sympathy (My family sympathizes and understands when I feel sad), feelings (I feel free to share inner feelings with members of my family), together (Members of our family are encouraged to work together in dealing with family problems), care (We show that we care for each other in our family).

Figure 5: Sense of failure as a symptom of depression



Hypothesis: There is a significant difference between male and female with adolescent's level of depression.

The above graph illustrates the sense of failure as a symptom of depression. 42% of participants had no problems, 16% had slight problems, 30% had moderate and severe problems were experienced by 12%.

Chi-square table 1.

Chi-square Tests

	Value	df	Asymp. Sig (2-sided)
Pearson Chi-square	2.269	3	.518
Likelihood Ratio	2.292	3	.514
Linear-by-linear Association	1.186	1	.276
N. of valid cases	50		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 4.00.

The chi-square was computed to test the relationship between the variable "gender" and " sense of failure " as a symptom of depression. The chi-square results show that there is no statistical evidence to support the hypothesis that there is a significant difference between male and female with adolescents' level of depression.

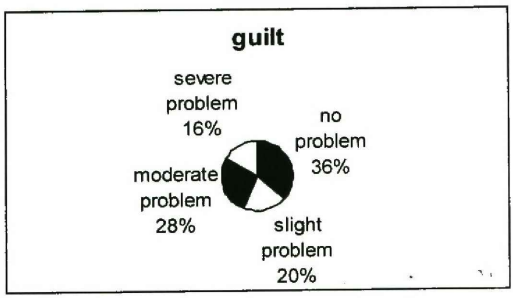
Table 3: Sense of failure by age, gender and family relationship

		Sense of failure				*Total*	*%*
		No problem	Slight problem	Moderate problem	Severe problem		
Total		**21 (42.0)**	**8(16.0)**	**15(30.0)**	**6(12.0)**	**50**	**100**
Gender	Male	11 (24.4)	4(16.0)	8(32.0)	2(8.0)	**25**	50
	Female	10 (40.0)	4 (16.0)	7(28.0)	4 (16.0)	**25**	50
Total		**21 (42.0)**	**8(16.0)**	**15(30.0)**	**6(12.0)**	**50**	**100**
Feelings	S. Agree	3(14.3)	0(0)	3(20.0)	0(0)	**6**	12.0
	Agree	4(19.0)	2(25.0)	4(26.7)	2(33.3)	**12**	24.0
	Uncertain	3(14.3)	1(12.5)	1(6.7)	0(0)	**5**	10.0
	Disagree	5(23.8)	1(12.5)	4(26.7)	2(33.3)	**12**	24.0
	S.Disagree	6(28.6)	4(50.0)	3(20.0)	2(33.3)	**15**	30.0
Total		**21**	**8**	**15**	**6**	**50**	**100**

S.Disagree – Strongly Disagree

In regard to gender, more females than males experienced s sense of failure. 24.4% of males and 40.0% of females didn't indicate any failure; while only 8% of males and 16% of females agreed to the question "I feel I am a complete failure as a person.

Figure 6: Guilt as a symptom of depression



Guilt is also illustrated as one of the symptoms of depression. 36% showed no problems, 20% had a slight problem, 28% experienced moderate problems and only 16% indicated severe problems with guilt.

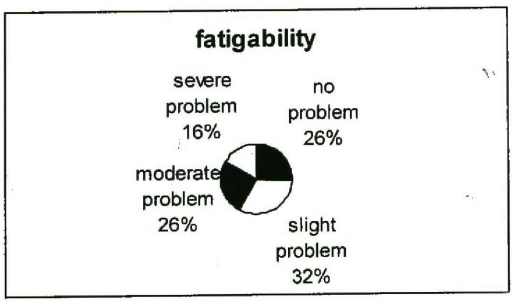
Table 4: Guilt by age, gender and family relationship

		Guilt				*Total*	*%*
		No problem	Slight problem	Moderate problem	Severe problem		
Total		**18 (36.0)**	**10 (20.0)**	**14(28.0)**	**8(16.0)**	**50**	**100**
Gender	Male	9 (36.0)	5 (20.0)	8(32.0)	3(12.0)	**25**	50
	Female	9 (36.0)	5 (20.0)	6(24.0)	5(20.0)	**25**	50
Total		**18(36.0)**	**10(20.0)**	**14 (28.0)**	**8(16.0)**	**50**	**100**
Feelings	S. Agree	2(11.1)	0(0)	4(28.6)	0(0)	**6**	12.0
	Agree	3(16.7)	1(10.0)	5(35.7)	3(37.5)	**12**	24.0
	Uncertain	3(16.7)	2(20.0)	0(0)	0(0)	**5**	10.0
	Disagree	6(33.3)	2(20.0)	2(14.3)	2(25.0)	**12**	24.0
	S.Disagree	4(22.2)	5(50.0)	3(21.4)	3(37.5)	**15**	30.0
Total		**18**	**10**	**14**	**8**	**50**	**100**

S.Disagree – Strongly Disagree

It was interesting to note that the same number of both male and female participants gave the same response to the question "I don't feel particularly guilty". 36% of both males and females agreed with the statement.

Figure 7: Fatigue as a symptom of depression



The above table shows the symptom of depression. Most of the participants i.e. 32% had slight problems and severe problems were experienced by only 16% of participants.

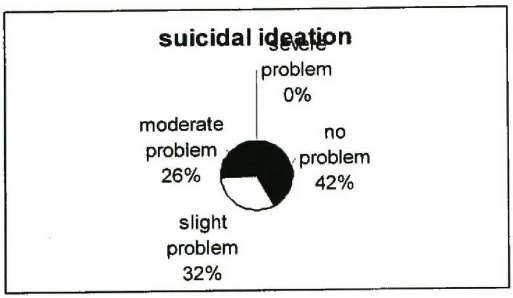
Table 5: Fatigability by age, gender and family relationship

		Fatigability				Total	%
		No problem	Slight problem	Moderate problem	Severe problem		
Total		**13 (26.0)**	**16(32.0)**	**13(26.0)**	**8(16.0)**	**50**	**100**
Gender	Male	7 (28.0)	10(40.0)	5(20.0)	3(12.0)	**25**	50
	Female	6 (24.0)	6 (24.0)	8(32.0)	5 (20.0)	**25**	50
Total		**13 (26.0)**	**16(32.0)**	**13(26.0)**	**8 (16.0)**	**50**	**100**
Feelings	S. Agree	2(15.4)	0(0)	4(30.8)	0(0)	**6**	12.0
	Agree	3(23.1)	4(25.0)	2(15.4)	3(37.5)	**12**	24.0
	Uncertain	1(7.7)	4(25.0)	0(0)	0(0)	**5**	10.0
	Disagree	3(23.1)	5(31.3)	3(23.1)	1(12.5)	**12**	24.0
	S.Disagree	4(30.8)	3(18.8)	4(30.8)	4(50.0)	**15**	30.0
Total		**13**	**16**	**13**	**8**	**50**	**100**

S.Disagree – Strongly Disagree

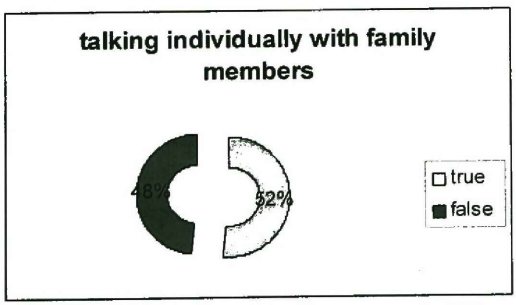
The test depicts slight problem in all gender and family relationships groups on fatigability. In regard to the question " It takes an extra effort to get started at doing something", most participants agreed with it. Few participants show a severe problem, depicting that few depressed adolescents can't do any work at all. The above table displays the relationship between the variables (gender and family relationship) and fatigability.

Figure 8: suicidal ideation as a symptom of depression



The above graph indicates that suicidal ideation is symptom of depression that respondents showed no problem with it. This is illustrated by 42% of adolescents who had no problem, 32% of respondents had a slight problem and those with a moderate problem were 26% of the sample.

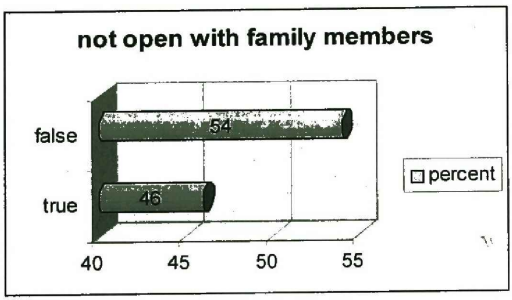
Figure 9: Recorded ability to talk individually with family members



Hypothesis: Depressed adolescents will show social isolation from family members.

The test results depict that the majority of participants communicate with members of their family. 48% of participants responded false to the question " I spend some talking individually with each member of the family". The above graph shows significance of talk in family relationship.

Figure 10: Recorded openness with family members



54% of participants responded false to the question "I am not really open with members of my family", while 46% disagreed, indicating their limited communication with family members.

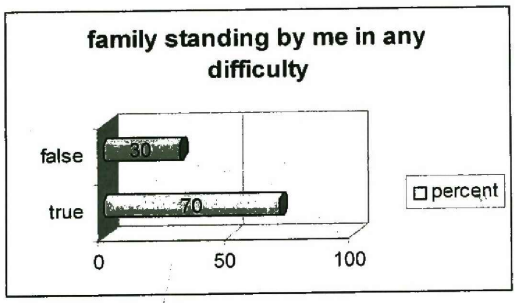
Table 6: Openness with family members by gender and family relationship

		Not very open with members of my family				Total	%
		True	%	False	%		
Total		**23**	**46.0**	**27**	**54.0**	**50**	**100**
Gender	Male	11	44.0	13	56.0	**25**	100
	Female	12	48.0	13	52.0	**25**	100
Total		**23**	**46.0**	**27**	**54.0**	**50**	**100**
Feelings	S. Agree	4	17.4	2	7.4	**6**	12.0
	Agree	6	26.1	6	22.2	**12**	24.0
	Uncertain	4	17.4	1	3.7	**5**	10.0
	Disagree	5	21.7	7	25.9	**12**	24.0
	S .Disagree	4	17.4	11	40.7	**15**	30.0
Total		**23**	**100**	**27**	**100**	**50**	**100**

S.Disagree – Strongly Disagree

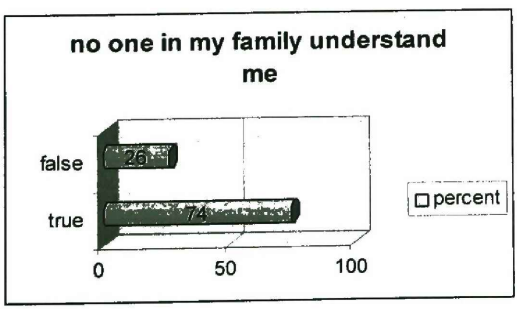
In regard to gender, 44%of males are not open to family members as compared to 48% of females.

Figure 11: Recorded support by family members



The majority of respondents feel that their family will stand by them in any difficult. This is suggested by the results in which 70% agreed with the statement while 30% disagreed with the statement.

Figure 12: Recorded understanding by family members



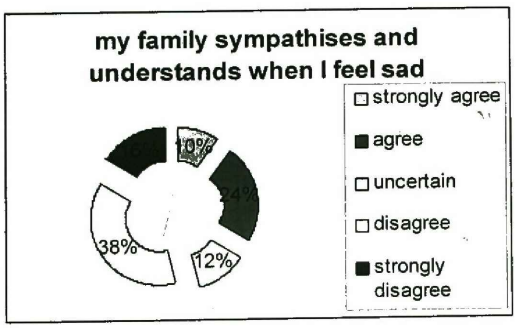
The above table indicated that many adolescents don't feel understood by family members. This is shown by 74% who don't feel understood as compared to 26% who felt understood.

Table 7: Understanding by family members in terms of gender and family relationship

		I don't think that anyone in my family really understand me				Total	%
		True	%	False	%		
Total		**37**	**74.0**	**13**	**26.0**	**50**	**100**
Gender	Male	17	68.0	8	32.0	**25**	100
	Female	20	80.0	5	20.0	**25**	100
Total		**32**	**74.0**	**13**	**26.0**	**50**	**100**
Feelings	S. Agree	4	10.8	2	15.4	**6**	12.0
	Agree	10	27.0	2	15.4	**12**	24.0
	Uncertain	4	10.8	1	7.7	**5**	10.0
	Disagree	8	21.6	4	30.8	**12**	24.0
	S. Disagree	11	29.7	4	30.8	**15**	30.0
Total		**37**	**100**	**13**	**100**	**50**	**100**

In regard to gender, more females than males thought that no one in the family understood them. However, the majority of both sexes didn't feel understood, 74% of participants didn't feel understood as compared to 26% who felt understood.

Figure 13: Recorded sympathizing by family of sad feelings



The majority of respondents disagreed with the statement "My family sympathizes and understands when I feel sad". This is illustrated by 38% who disagreed and 16% who strongly agreed while 24% agreed and 10% strongly agreed.

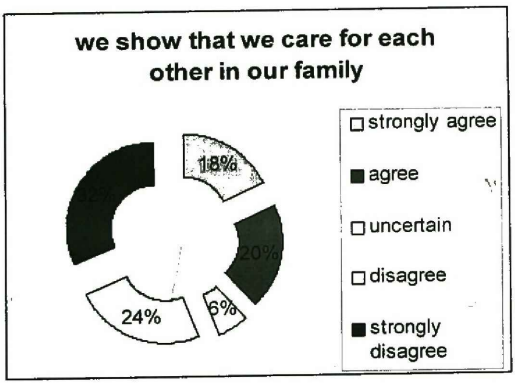
Table 8: Family's acknowledgement of strength and positive qualities by gender and family relationship

		I feel that members of my family acknowledge my strength and positive qualities				Total	%
		True	%	False	%		
Total		**27**	**54.0**	**23**	**46.0**	**50**	**100**
Gender	Male	15	60.0	10	40.0	**25**	100
	Female	12	48.0	13	52.0	**25**	100
Total		**27**	**54.0**	**23**	**46.0**	**50**	**100**
Feelings	S. Agree	3	11.1	3	13.0	**6**	12.0
	Agree	6	22.2	6	26.1	**12**	24.0
	Uncertain	4	14.8	1	4.3	**5**	10.0
	Disagree	7	25.9	5	21.7	**12**	24.0
	S.Disagree	7	25.9	8	34.8	**15**	30.0
Total		**27**	**100**	**23**	**100**	**50**	**100**

S.Disagree – Strongly Disagree

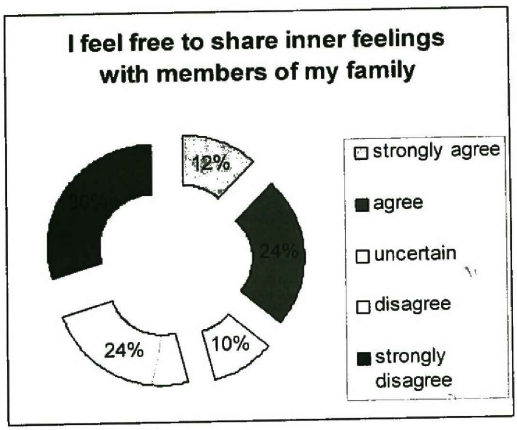
The above table illustrates the relationship between social support and gender.60% of male and 48% of female agreed with the statement "I feel that my family acknowledge my strength and positive qualities.11.1% of participants with good family relationship agreed with a statement compared to 15% of participants with poor family relationship disagreed with the statement.

Figure 14: Recorded caring for each family member



56% of respondents do not show that they care for each other in their family as compared to 38% who showed that they care for each other.

Figure 15: Recorded sharing of feelings with family members



The majority of respondents are not open with family members. This is indicated by 54% of respondents who do not feel free to share inner feelings with members of their family as compared to 36% who do.

Table 9: Fatigability by family relationship

		Fatigability				Total %
		No problem %	Slight problem %	Moderate problem %	Severe problem %	
I have a good relationship with most members of my family	True	11 (39.3)	10(35.7)	5(17.9)	2(7.1)	**28(100)**
	False	2 (9.1)	6(27.3)	8(36.4)	6(27.3)	**22(100)**
Total		**13 (26.0)**	**16(32.0)**	**13(26.0)**	**8 (16.0)**	**50(100)**
I don't think that anyone in my family understand me	True	5 (13.5)	12 (32.4)	12(32.4)	8(21.6)	**37(100)**
	False	8 (61.5%)	4 (30.8%)	1(7.7%)	0 (0%)	**13(100)**
Total		**13 (26.0)**	**16 (32.0)**	**13 (26.0)**	**8 (16.0)**	**50(100)**
I feel that my family acknowledge my strength and positive qualities	True	9 (33.3)	11(40.7)	5(18.5)	2 (7.4)	**27(100)**
	False	4 (17.4)	5(21.7)	8(34.8)	6 (26.1)	**23(100)**
Total		**13 (26.0)**	**16(32.0)**	**13(26.0)**	**8 (16.0)**	**50(100)**
I am not very open with members of my family	True	2 (8.7)	7(30.4)	9(39.1)	5 (21.7)	**23(100)**
	False	11 (40.7)	9 (33.3)	4(14.8)	3 (11.1))	**27(100)**
Total		**13 (26.0)**	**16 (32.0)**	**13 (26.0)**	**8 (16.0)**	**50(100)**
We show that we care for each other in our family	SA	2 (22.2)	2 (22.2)	4 (44.4)	1 (11.1)	**9**
	A	3 (30.0)	3 (30.0)	2 (20.0)	2 (20.0)	**10**
	U	1 (33.3)	2 (66.7)	0	0	**3**
	D	4 (33.3)	5 (41.7)	3 (25.0)	0	**12**
	SD	3 (18.8)	4 (25.0)	4 (25.0)	5(31.3)	**16**
Total		**13 (26.0)**	**16 (32.0)**	**13 (26.0)**	**8 (16.0)**	**50**
I feel free to share inner feelings with members of my family	SA	2	0	4	0	**6**
	A	3	4	2	3	**12**
	U	1	4	0	0	**5**
	D	3	5	3	1	**12**
	SD	4	3	4	4	**15**
Total		**13**	**16**	**13**	**8**	**50**

Hypothesis: Adolescent with poor family relationship show higher level of depression than those with good family relationship.

39.3% of participants with good relationship with most family members didn't experience fatigue compared to 27.3% of participants with bad relationship with most family members have fatigue, that is can't do any work at all. The majority of participants who experiences a slight problem with fatigue agreed to the question "I don't think that anyone in my family understand me". 61.5% of participants who thought understood by family members didn't experience any problem with fatigue. The relationship between "I feel that my family acknowledge my strength and positive qualities and variable fatigability, is indicated by 33.3% with no problem with fatigue and 30.8% with slight problem with fatigue felt that their strength and positive qualities are acknowledge by family. The majority of participants (30.4%) with a slight problem of fatigue agreed to the question "I am not very open with members of my family".

Table 10: Sense of failure by family relationship

		Sense of failure				Total %
		No problem %	Slight Problem %	Moderate problem %	Severe problem %	
I have a good relationship with most members of my family	True	18 (64.3)	6 (21.4)	3 (10.7)	1 (3.6)	**28(100)**
	False	3 (13.6)	2 (9.1)	12 (54.5)	5(22.7)	**19(100)**
Total		**21 (42.0**	**8 (16.0)**	**15(30.0)**	**6(12.0)**	**50(100)**
I don't think that anyone in my family understand me	True	11 (29.7	7(18.9)	13(35.1)	6(16.2)	**37100)**
	False	10 (76.9%)	1 (7.7%)	2 (15.4%)	0 (0%)	**13(100)**
Total		**21 (42.0)**	**8(16.0)**	**15(30.0)**	**6(12.0)**	**50(100)**
I feel that my family acknowledge my strength and positive qualities	True	17 (63.0)	3(11.1)	6(22.2)	1 (3.7)	**27(100)**
	False	4 (17.4)	5 (21.7)	9(39.1)	5(21.7)	**23(100)**
Total		**21 (42.0)**	**8 (16.0)**	**15 (30.0)**	**6 (12.0)**	**50(100)**
I am not very open with members of my family	True	5 (21.7)	3 (13.0)	12 (52.2)	3 (13.0)	**23(100)**
	False	16 (59.3)	5 (18.5)	3(11.1)	3 (11.1)	**27(100)**
Total		**21 (42.0)**	**8 (16.0)**	**15 (30.0)**	**6 (12.0)**	**50(100)**
We show that we care for each other in our family	SA	3	1	5	0	**9**
	A	5	1	2	2	**10**
	U	2	0	1	0	**3**
	D	5	2	4	1	**12**
	SD	6	4	3	3	**16**
Total		**21**	**8**	**15**	**6**	**50**
I feel free to share inner feelings with members of my family	SA	3	0	3	0	**6**
	A	4	2	4	2	**12**
	U	3	1	1	0	**5**
	D	5	1	4	2	**12**
	SD	6	4	3	2	**15**
Total		**21**	**8**	**15**	**6**	**50**

The table above displays the relation between different family support questionnaire and the variable sense of failure. 64.3% with a good relationship with family members didn't experience failure as compared to 54.5% with a bad relationship with family members had a moderate problem with failure. Interestingly, 76.9%of participants who didn't experience a failure agreed to the question "I don't think that anyone in my family understand me". 63.3% of participants who feel that family acknowledges their strength and positive qualities as compared to 21.7% of participants who feel that their strength and positive qualities are not acknowledged, felt as complete failures.59.3% of participants who are open with the family didn't feel like failures.

Chi-square table 2

Chi-square Tests

	Value	df	Asymp. Sig (2-sided)
Pearson Chi-square	8.217	12	.768
Likelihood Ratio	9.595	12	.651
Linear-by-linear Association	.000	1	.995
N. of valid cases	50		

b. 18 cells (90.0%) have expected count less than 5. The minimum expected count is .36

Chi-square table indicates that there is no statistical significance to support the hypothesis that adolescents with poor family relationship show higher levels of depression than those with good family relationship.

Table 11: Guilt by family relationship

		Guilt				Total %
		No problem %	Slight problem %	Moderate problem %	Severe problem %	
I have a good relationship with most members of my family	True	17 (60.7)	6 (21.4)	3 (10.7)	2 (7.1)	**28(100)**
	False	1 (4.5)	4 (18.2)	11 (50.0)	6 (27.3)	**22(100)**
Total		**18 (36.0)**	**10 (20.0)**	**14 (28.0)**	**8 (16.0)**	**50(100)**
I don't think that anyone in my family understand me	True	8 (21.6)	8 (21.6)	13 (35.1)	8 (21.6)	**37(100)**
	False	10 (76.9)	2 (15.4)	1 (7.7)	0 (0)	**13(100)**
Total		**18 (36.0)**	**10 (20.0)**	**14 (28.0)**	**8 (16.0)**	**50(100)**
I feel that my family acknowledge my strength and positive qualities	True	16 (59.3)	5 (18.5)	5(18.5)	1(3.7)	**27(100)**
	False	2 (8.7)	5 (21.7)	9 (39.1)	7 (30.4)	**23(100)**
Total		**18 (36.0)**	**10 (20.0)**	**14(28.0)**	**8 (16.0)**	**50(100)**
I am not very open with members of my family	True	4 (17.4)	4 (17.4)	11 (47.8)	4 (17.4)	**23(100)**
	False	14 (51.9)	6 (22.2)	3 (11.1)	4 (14.8)	**27(100)**
Total		**18 (36.0)**	**10 (20.0)**	**14(28.0)**	**8 (16.0)**	**50(100)**
We show that we care for each other in our family	SA	2	1	6	0	**9**
	A	4	0	3	3	**10**
	U	2	1	0	0	**3**
	D	5	4	2	1	**12**
	SD	5	4	3	4	**16**
Total		**18**	**10**	**14**	**8**	**50**
I feel free to share inner feelings with members of my family	SA	2	0	4	0	**6**
	A	3	1	5	3	**12**
	U	3	2	0	0	**5**
	D	6	2	2	2	**12**
	SD	4	5	3	3	**15**
Total		**18**	**10**	**14**	**8**	**50**

The above table displays the relationship between various family support variable and guilt. The majority of participants (60.7%) had a good relationship with most family members and didn't feel particularly guilt. 21.6% of participants who agreed to the question "I don't think that anyone in my family understand me", had no problem with guilt. 8.7% of participants who feel that their positive qualities and strength are not acknowledged didn't experience guilt as compared to 59.3% who felt that family acknowledges their strength and positive qualities. 47.8% who agreed to the question that "I am not very open with members of my family" had a moderate problem with guilt.

CHAPTER 5
DISCUSSIONS

5.1. DISCUSSION

During adolescence, it is not uncommon to experience peaks and valleys of optimism and pessimism, pride and shame, or love and hate. An adolescent is made increasingly aware of his or her separateness by the power of emotional reactions that are not shared by parents and siblings. Among the more troublesome of these emotions are shame, embarrassment, guilt, shyness, depression, and anger (Weissmann et. al., 1992). The present study has shown that adolescents with poor family relationship does not necessary show higher levels of depression than those with good family relationship. In contrast, the findings of Shaffer & Craft (1988) concluded that depressed adolescent who get along better with families tend to be better adjusted socially, feel better about themselves and have more of a sense of belonging.

Beyers & Goossens (1999) indicated that people often turn to others for help and guidance during emotional stress. They first seek support from family members. Social supports refer to the availability and quality of interpersonal resources that people can call on during emotional stress. Social supports can provide guidance, feedback and positive social interactions. People with effective support networks tend to show fewer symptoms of both physical and mental disorders in the face of stress than people without such support (Hofer & Noack, 1998). Therefore, social supports may help decrease the impact of stress on mental health (Hodgman, 1985). Thus, the majority of respondents agreed that some of their family members would stand by them in almost any difficulty while 26.7% didn't agree that their family would stand by them.

According to Hodgman (1985), adolescence is a period of rapid growth physically, cognitively and emotionally. This is a time of stress and confusion for

many adolescents. Therefore, family support is particularly important in the normal development of young people. When this support is not available or inconsistent to the young person, depression and anger may ensue with dire consequences. This is shown by 33.3% of adolescents with good family relationship and displayed no problem with failure as compared with 2.2% of respondents with good family relationship and displayed severe problem with failure.

Research has shown, however, that teenagers still benefit from a strong support system. Teens who report supportive relationships with parents have higher levels of psychological well-being. This results are consisted with the findings of Monroe et. al. (1999) that time spent at home, and in positive interactions with adults, appears to have a positive consequences for adolescents. However, the results showed no significance between good family relationship and adolescents' lower level of depression. This may suggest that family relationship can actually lead or increase adolescents' level of depression.

Relationships with parents change a lot during adolescence. Often daily conflict increases, and relationships change from parental control to parental guidance. Because adolescence is a time for separating from the direct, day-to-day influence and control of parents, it is also a time when youngsters minimize their dependence upon parents for love, support, and security. As teenagers try to establish their identity, they have to adjust to the loss of childhood security and accept increasing responsibility (Steinberg, 2001). As teenager's work toward independence and self-control, parent's attitude to their struggle is crucial to their success.

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influence and control of parents, it is also a time when youngsters minimize their dependence upon parents for love, support, and security. As teenagers try to establish their identity, they have to adjust to the loss of childhood security and accept increasing responsibility (Noom et. al., 1999). As teenager's work toward independence and self-control, parent's attitude to their struggle is crucial to their success.

Another significant finding of this study is that depressed adolescents will show social isolation from family members. The majority of participants who have good relationship with the family indicate a more open communication with family members. There is a correlation between good family relationship and adolescents being open with family members. Thus, 75% of participants who have good family relationship are very open with the family.

Family interaction patterns can exert tremendous influence on a child's personality development, determining the child's sense of self-worth and the acquisition of appropriate social skills (Shaffer & Craft, 1999). Inconsistent communication or distorted patterns of operation can cause children to develop a misconception of reality. Shaffer & Craft (1999) strongly believes that the family is truly an individualized system of feeders and those fed, directors and the directed, supporters and the supported. Pathological family systems are often the results of dysfunctional communication patterns. These support the finding that depressed adolescents who have a bad family relationship, are not very open with members of the family. While frequent, open communication between adolescents and their parents contributes to a positive relationship, it is misleading to assume that these interactions are always positive in tone. It is hard work for parents and adolescents to keep channels of communication open(Shiner & Marmorstein, 1998).

Social isolation or the sense that there is nobody you can talk to about your private feelings can negatively affect your health. The results of this study confirm the hypothesis, which states that depressed adolescent socially isolates from family. An important source of support during the complex transition of adolescence is family support. Depression is an illness that has a profound impact on family members who live with the person as well as love the person. Some people who are depressed withdraw from people and isolate themselves (Wells et. al., 1985).

The study also indicates that there is no significant difference between male and female adolescents level of depression. This finding is opposed by other research findings that indicate that by age 13, a dramatic shift occurs, and more than twice as many girls as boys are depressed, a proportion that persists into adulthood.

Gender seems to be related to the level of stress during the stage of adolescence, 24% of males and 40% of females had no problem with sense of failure while 8% of males and 16% of females experienced severe problem with failure. In fact, recent research focusing on the impact of stress on biological functioning shows some differences between males and females. Individual girls develop at different rates, and pubertal age is more accurate than chronological age in predicting depression.

During early adolescence, as boys and girls develop different explanatory styles, they also develop different styles of coping in stressful situations. Research has shown that rumination is one factor associated with higher rates of depression among adolescent girls (Kovacs et. al., 1984). Boys, in contrast, use more problem solving and distraction techniques. They handle their stress the only way they know how, with anger and impulsive or inappropriate behavior. Therefore, both boys and girls experience almost the same level of depression during emotional turmoil (Steinberg, 2001).

The results of this study disconfirmed the hypothesis, which states that there is a significant difference between male and female with adolescents' level of depression. The chi-square results indicate that there is no statistical evidence to support the hypothesis. This may suggest that boys' distractive behaviour lead them to depression. This finding concurs with that of Wells (1985), which purports that a large number of boys than girls experience excessive stress during pubertal and adolescent stage of development.

5.2. LIMITATIONS OF THE STUDY

The limitations of the study are as follows:

It should be noted that the sample drawn was from a single geographic area and thus represents a relatively restricted range of community and hospital conditions. Therefore, future research should include a larger more diverse sample. Additional research including adolescents from other mental institution would help to eliminate the generalizing of these findings. It is on this that the findings of this study cannot be generalized to all depressed adolescents.

Even though the researcher to cover much about family support and its role in depressed adolescence, this may be inadequate since family members' opinions were not included. This calls for more advanced studies to counteract the limitation of study.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1. INTRODUCTION

The teen years are emotionally turbulent, even for adolescents who are loved and well adjusted. For kids who feel neglected or abused in any way, being a teenager can be a living hell. No wonder that many teens experience significant depression. Adolescent depression is increasing at an alarming rate. Recent surveys indicate that as many as one in five teens suffers from clinical depression. This is a serious problem that calls for prompt, appropriate treatment.

6.2. RECOMMENDATIONS

One of the most promising findings is the strong power of a positive relationship between parent and child. Adolescents who felt their parents were there for them, who understood and respected them were more likely to feel better about themselves. The following guidelines can also be used as a preventative measure.

6.2.1. Form a good relationship with the youth

During early childhood development, children generally bond with their parents and they have a good and trusting relationship. They grow up trusting their outside world and see it as a safe place where they can continue to grow and develop. Their growth reaches its peak during adolescence. The youth needs to come to terms with rapid physical growth, conflicts between parental and peer values and ideals, emotional and physical intimacy with the opposite sex and the uncertainty about his/her future career. These developmental tasks can generate

a great deal of pressure but most young people complete them successfully without too many difficulties.

Despite popular belief to the contrary, most teenagers do want a close relationship with their parents even though they may not admit to it openly. The relationship with their parents may have changed in form and content but it is in fact a continuum of their past relationship. Parents have to grow and change in parallel with their teenagers. It is a two way process. If the relationship is there, teenagers generally acknowledge and respect their parents' values and they want their advice and support, especially at times of stress.

A good relationship will open up communication between the youth and his/her parents. This can be a life saving safety valve to the depressed and troubled teenager.

6.2.3. Relationship between teenagers and their parents can be improved by:

a. Spending quality time with young people

Quality time is a cliché frequently used in child rearing literature and it is met with a certain degree of cynicism. However, a good relationship between a youth and his/her parents cannot occur unless they spend time together. The amount of time spent in conflict is huge. Why not spend some of this time having fun together?

b. Listening to teenagers, not only to what is being said, but also to the covert messages

Teenagers commonly complain that their parents are keen to give advice but they don't listen to their points of view. Messages sent by teenagers may at times be tangential, contradicting and confusing. Parents will need to "de-code" these scrambled messages to get in touch with their children's feelings. In many

instances this may mean an interpretation of their body language. Non-verbal action can talk much louder than conversational language.

c. Being supportive and not intrusive

There is a fine line between being supportive and being intrusive. It is important for parents to acknowledge the upset and distress shown by their teenage children, but not interrogating and demanding to know the secrets of their distress. Teenagers will generally talk to their parents about their problems when they are ready. Respect the fact that they can solve many problems on their own without the support of others. Support is there for them to use but it must not be imposed on them.

d. Encouraging the appropriate expression of emotions

Many teenagers tend to either hide their emotions or they show them in an explosive manner, thus leading to their parents' comments about their moodiness. Encourage them to show and share their feelings of joy, happiness, and excitement in their successes. They can then show and share their sadness, anxiety, distress and disappointment. Both positive and negative feelings must be contained so that they are not running wild and out of control.

e. Set reasonable limits

It is a tempting world out there. Parents have the responsibility to set clear boundaries in areas where mistakes have lifetime consequences. They also must pay enough attention to their children's activities to ensure that the limits they set are enforced.

f. Stay involved in your children's lives

This can be difficult during those adolescent years when teens are struggling for independence, but when you make the effort, and take the time to be there for them, they will know you care.

g. Know where your child is and who their friends are

As our children become adolescents, their peers play an important role in influencing their behaviour, attitudes and choices. We can't control everyone they see. But we can make it a point to get to know their friends and the parents of their friends.

h. Stay in touch with the school and teachers

Work together to make school as important and successful an experience as possible for your child. It is a crucial key to your child's future.

6.2.2. Early intervention in stressful situations

Severe emotional symptoms are frequently found in individuals facing or following significant life events. Support from parents and family members are particularly important to prevent despair and suicidal ideation. This can be achieved by being in touch with the youth's emotional state. Just because teenagers don't show their feelings readily, it does not mean that they are not concerned about impending major life events or feel distressed after a personal disaster. Have empathy with them. They want to be understood by their parents. Sensitive listening and appropriate advice or debriefing will help.

The successful negotiation and resolution of a stressful situation can be a confidence booster to the youth.

6.2.3. Be vigilant of changes in behaviour

Be wary if there is a sudden excessive elevation of the youth's mood in someone who was previously severely depressed. This does not mean that the youth is getting better. The youth may have in fact finally decided to commit suicide and there is a sense of relief and therefore the improved mood and activity level.

A teenager who is grossly agitated is also at risk. Drug, depression, anxiety or psychosis can cause the agitation. In this instance, the suicide act may be the youth's attempt to relieve the internal distress and agitation.

6.2.4. Seek advice or help from professionals if in doubt

It is not easy for parents to come to accept that their teenager is emotionally troubled, not to mention suicide attempt. Parents tend to blame themselves and ask themselves many "if only" and "why questions." Professional assistance is frequently required for not only the teenager, but also the family.

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Dear Participant

I am a masters student in clinical psychology at the Department of Psychology of the University of North West. I am undertaking this research study as part of my program.

The study examines the role of family support among Major Depressive Disorder adolescent. Your participation will be highly appreciated in this study. There are no right and wrong answers to the questions, only your honest opinion is important.

Your responses are confidential, therefore your name and surname is not necessary.

Thank you for your co-operation

Vidoh Masilo

Part 1:

Research Instrument:

Gender:

- Male ☐
- Female ☐

Age Group:

- 12– 14 ☐
- 15 – 17 ☐
- 18 – 20 ☐

Level of Education:

- Grade 1 – Std 5 ☐
- Std 6 - Std 8 ☐
- Std 9 - Std 10 ☐
- Post-Matric qualification ☐
- Never Attended School ☐

Marital Status of Parents:

- Single ☐
- Married ☐
- Separated ☐
- Divorced ☐
- Widowed ☐
- Remarried ☐

Residence:

- School/University Residence ☐
- Living with Parents ☐
- Living with Relatives ☐

PART 2:

Differential Loneliness Scale:

Tick a (x) in the suitable answer that best applies to you, which is either True or False

	True	False
1. I don't get along very well with my family.		
2.I often become shy and retiring in the company of relatives.		
3. Some of my family will stand by me in almost any difficulty.		
4. I spend some time talking individually with each member of my family.		
5. I don't think that anyone in my family really understand me.		
6. My family members are generally too busy with concerns to bother about my problems.		
7. Members of my family give me the kind of support that I need.		
8. I am not very open with members of my family.		
9. I have a good relationship with most members of my immediate family.		
10. I get plenty of help and support form family.		
11. I seem to have little to say to members of my family.		
12. I really feel that I belong to a family.		
13. My family is quite critical of me.		
14. Generally I feel that members of my family acknowledge my strength and positive qualities.		
15. Members of my family are relaxed and easy-going with each other.		
16. I have little contact wit members of my family.		
17. As much as possible, I avoid members of my family		
18. My family usually values my opinion when a family decision is to be made.		

PART 3:

Beck's Depression Scale

Please read each group statements carefully. Then pick out the one statement in each group, which best describe the way you have been feeling **The past week including today.** If more than one statement in the group seems to apply equally well, choose only one and mark the corresponding block.

1. a.) I do not feel sad.
   b.) I feel sad.
   c.) I am sad all the time and I can't snap out of it.
   d.) I am so sad or unhappy that I can't stand it.

2. a.) I am not particularly discouraged about the future.
   b.) I feel discouraged about the future.
   c.) I feel I have nothing to look forward to.
   d.) I feel that the future is hopeless and that things can't improve.

3. a.) I do not feel like a failure.
   b.) I feel I have failed more than the average person.
   c.) As I look back on my life, all I can see is a lot of failures.
   d.) I feel I am a complete failure as a person.

4. a.) I get as much satisfaction out of things as I used to.
   b.) I don't enjoy things the way I used to.
   c.) I don't get real satisfaction out of anything anymore.
   d.) I am dissatisfied or bored with everything.

5. a.) I don't feel particularly guilty.
   b.) I feel guilty a good part of the time.
   c.) I feel quite guilty most of the time.
   d.) I feel guilty all of the time.

6. a.) I don't feel I am being punished.
   b.) I feel I may be punished.
   c.) I expect to be punished.
   d.) I feel I am being punished.

7 a.) I don't feel disappointed in myself.
   b.) I am disappointed in myself.
   c.) I am disgusted with myself.

d.) I hate myself. ☐

8 a.) I don't feel I am any worse than anybody else. ☐
b.) I am critical of myself for my weakness or mistake. ☐
c.) I blame myself all the time for my faults. ☐
d.) I blame myself for everything bad that happens. ☐

9 a.) I don't have thoughts of killing myself. ☐
b.) I have thoughts of killing myself, but I would not carry it out. ☐
c.) I would like to kill myself. ☐
d.) I would kill myself if I had the chance. ☐

10 a.) I don't cry anymore than usual. ☐
b.) I cry more now than I used to. ☐
c.) I cry all time now. ☐
d.) I used to be able to cry, but now I can't cry even when I want ☐

11 a.) I am no more irritated now than I ever am. ☐
b.) I get annoyed or irritated more easily than I used to. ☐
c.) I feel irritated all the time now. ☐
d.) I don't get irritated at all by things that used to irritate me. ☐

12 a.) I have not lost interest in other people. ☐
b.) I am less interested in other people than I used to be. ☐
c.) I have lost most of my interest in other people. ☐
d.) I have lost all of my interest in other people. ☐

13 a.) I make decisions about as well I ever could. ☐
b.) I put off making decisions more than I used to. ☐
c.) I have greater difficulty in making decisions than before. ☐
d.) I can't make decision at all anymore. ☐

14 a.) I don't feel I look any worse than I used to. ☐
b.) I am worried that I'm looking old or unattractive. ☐
c.) I feel permanent changes in my appearance make me look unattractive. ☐
d.) I believe that I look ugly. ☐

15 a.) I can work about as well as before. ☐
b.) It takes an extra effort to get started at doing something. ☐
c.) I have to push myself very hard to do anything. ☐
d.) I can't do any work at all. ☐

16 a.) I can sleep as well as usual.
b.) I don't sleep as well as I used to.
c.) I wake up 1 to 2 hours earlier than usual and find it hard to get back to sleep.
d.) I wake up several hours earlier than I used to and cannot get back to sleep.

17 a.) I don't get more tired than usual.
b.) I get tired more easily than I used to.
c.) I get tired from doing almost anything.
d.) I am too tired to do anything.

18 a.) My appetite is no worse than usual.
b.) My appetite is not as good as it used to be.
c.) My appetite is much worse now.
d.) I have no appetite at all anymore.

19 a.) I have not lost much wait, if any, lately.
b.) I have lost more than 2 kg.
c.) I have lost more than 4 kg.
d.) I have lost more than 6 kg.

20 a.) I am no more worried about my health than usual.
b.) I am worried about physical problems such as aches and pains or upset stomach or constipation.
c.) I am very worried about physical problems and it's hard to think of much else.
d.) I am so worried about physical problems that I cannot think about anything else.

21 a.) I have not noticed any recent change in my interest in sex.
b.) I am less interested in sex than I used to be.
c.) I am much less interested in sex now.
d.) I have lost interest in sex completely.

PART 4

THE FOLLOWING QUESTIONS WERE ADAPTED FROM FAMILY FUNCTIONING IN ADOLESCENCE QUESTIONNAIRE (FFAQ)

THERE ARE NO CORRECT OR INCORRECT ANSWERS TO THE QUESTIONS IN THIS QUESTIONNAIRE. IT CONTAINS A NUMBER OF STATEMENTS CONCERNING YOU AND YOUR FAMILY. READ EACH STATEMENT CAREFULLY AND SELECT ONE OF THE ANSWERS LISTED BELOW TO INDICATE TO WHAT EXTENT IT IS TRUE OF YOUR FAMILY.

1. In our family we don't spend our free time together.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

2. My family sympathizes and understands when I feel sad.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

3. If you say something in our family, the others ignore you.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

4. My parents let me help decide about matters that affect us all as a family.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

5. In a risky situation it is more important for me to do what my friends want, than to please my parents.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

6. My parents want me to try my best whatever I do.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

7. My mother cares about me and accepts me the way I am.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

8. My parents don't trust me.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

9. We have a relaxed atmosphere at home.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

10. We encourage and praise each other's efforts and successes in our family.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

11. I feel uncomfortable asking information about sex from my parents.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

12. Honesty is important in our family.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

13. My parents encourage me to talk about my views on matters even when their views are different from mine.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

14. In our family, everyone helps with the tasks at home.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

15. I feel free to share inner feelings with members of my family.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

16. Members of our family are encouraged to say what they really mean.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

17. Members of our family are encouraged to work together in dealing with family problems.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

18. People in my family get so angry that they throw things.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

19. We show that we care for each other in our family.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

20. I wonder if my parents really love me.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

21. We feel free to express our opinions in our family, but we consider each other's feelings.

Strongly agree		Agree		Uncertain		Disagree		Strongly disagree	

Table 4.16(b) Concentration of chlorophyll in diethyl ether after purification.

Total chlorophyll (mg/L)	7.12 x 2.116 + 16.8 x 0.636	= 25.751
Chlorophyll-*a* (mg/L)	9.93 x 2.116 – 0.78 x 0.636	= 20.516
Chlorophyll-*b* (mg/L)	17.6 x 0.636 – 2.8 x 2.116	= 5.269

In diethyl ether [10,19,59]

Total chlorophyll (mg/L) = $7.12D_{660} + 16.8D_{642.5}$

chlorophyll-*a* (mg/L) = $9.93D_{660} - 0.78D_{642.5}$

chlorophyll-*b* (mg/L) = $17.6D_{642.5} - 2.8D_{660}$

where $D_{642.5}$ and D_{660} are the absorbances at the specified wavelengths.

4.1.5 SUMMARY OF QUANTITIES OF CHLOROPHYLL EXTRACTED USING DIFFERENT METHODS

Table 4.17 is a summary of the relative quantities of chlorophyll extracted by the various methods of extraction employed in this research work.

Table 4.17 Summary of the relative quantities of chlorophyll extracted, using different solvents.

Extraction method	**Quantity of chlorophyll-*a* extracted (mg/L)**
Alumina column method (method 1) (pages 54 – 56)	1.453 (petroleum ether)
Silica gel column method (method 2) (pages 57 and 58)	10.870 (petroleum ether)
Improved silica gel column method (method 3) (pages 59 – 61)	21.957 (diethyl ether)
Winter extraction method (method 4) (pages 62 and 63)	20.516 (diethyl ether)

4.2 DEMETALLATION OF CHLOROPHYLL-*a*

Chlorophyll-*a* extract in petroleum ether (60-80°C) or diethyl ether was demetallated to form pheophytin-*a* by reacting the extract with an acid such as dilute hydrochloric acid or glacial acetic acid. The colour of the chlorophyll-*a* solution immediately changed from green to olive green. The pheophytin-*a* solution obtained was then analyzed by ultraviolet-visible and infrared spectroscopies in the regions 300 – 800 nm and 500 – 4000 cm^{-1}, respectively.

The ultraviolet-visible spectra of pheophytin-*a* obtained for the different extraction methods show absorption bands around 410, 506, 534, 562, 607 and 666 nm (Figures 4.11 and 4.17). the absorptions vary slightly with different solvents (petroleum ether versus diethyl ether).

The infrared spectra of pheophytin-*a* in petroleum ether obtained show major absorption bands at 2731 1931, 1617, 1523, 1378, 1029, 765 and 689 cm^{-1} (Figure 4.26).

The electrospray ionization mass spectrum of the pheophytin-*a* indicates a peak at *m/z* 593.2 and a 100% relative abundance (Figure 4.32).

Tables 4.12(a) and 4.18(a) show the wavelengths of maximum absorption and the absorbances at these wavelengths of the pheophytin-*a*. Tables 4.12(b) to 4.18(b) show the concentrations of total pheophytin and pheophytin-*a* in mg/L obtained in this analysis.

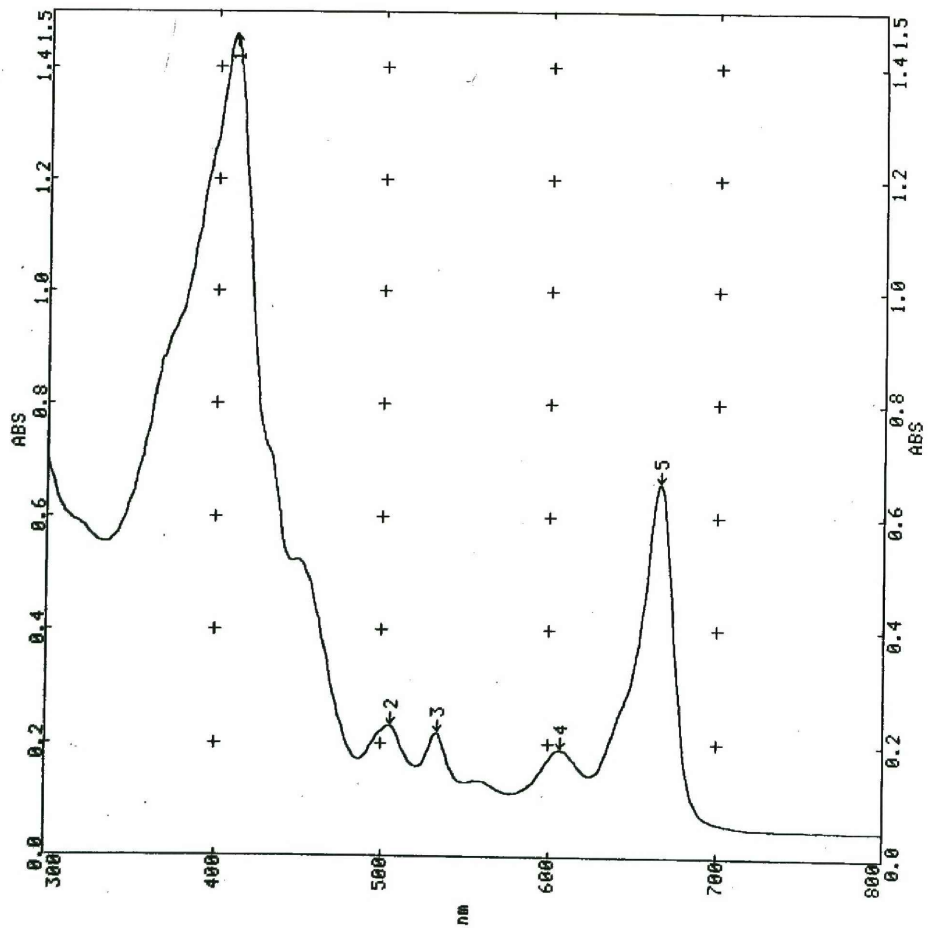


Figure 4.17 Absorption spectrum of pheophytin-*a* in diethyl ether after purification on a silica gel chromatographic column.

Table 4.18(a) Absorption band of pheophytin-*a* in diethyl ether after

Peaks	Wavelength (nm)	Absorbance
1	410	1.459
2	506	0.233
3	534	0.220
4	607	0.190
5	655	0.403
5	666	0.659

Table 4.18(b) Concentration of pheophytin-*a* in diethyl ether

Total pheophytin (mg/L)	6.75 x 0.659 + 26.03 x 0.403	= 14.938
Pheophytin-*a* (mg/L)	20.15 x 0.659 – 5.87 x 0.403	= 10.913

Total pheophytin (mg/L) $= 6.75D_{666} + 26.03D_{655}$

Pheophytin-*a* (mg/L) $= 20.15D_{666} - 5.87D_{655}$

where D_{655} and D_{666} are the absorbances at the specified wavelengths.

4.3 COMPLEXATION OF PHEOPHYTIN-*a*

Complexation of pheophytin-*a* with the metal ions cobalt(II), copper(II), chromium(III), nickel(II), and zinc were carried out. The metal pheophytin complexes were characterized by UV-visible and infrared spectroscopies.

Ultraviolet-visible spectra of these metal complexes were found to have mainly two absorption bands one between 407 and 430 nm and the other between 590 and 650 nm (Figures 4.18 – 4.23) The ultraviolet-visible spectra of these metal pheophytin complexes were compared with the ultraviolet-visible spectrum of copper chlorophyllin trisodium salt (Merck) Figure 4.19.

The infrared spectra of these metal pheophytin complexes in nujol show major absorption bands at the carbonyl stretching frequency at about 1700 cm^{-1}.

The mass spectrum analyzes of the cobalt(II) pheophytin-*a* (Figure 4.36) shows a peak with *m/z* ratio 648.66 and a relative abundance of 85 %.

The ultraviolet-visible, infrared and mass spectra of the metal pheophytin complexes are displayed in Figures 4.18 – 4.23, 4.24 – 4.31 and 4.32 – 4.37, respectively.

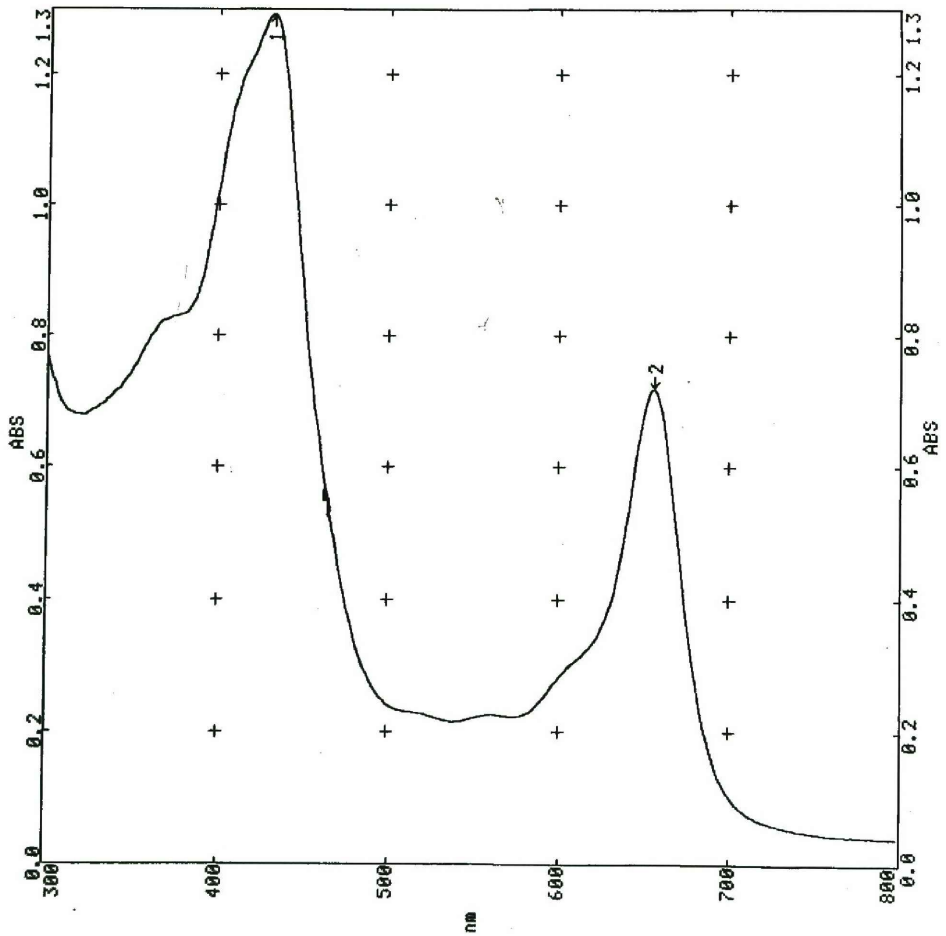


Figure 4.18 Absorption spectrum of cobalt(II) pheophytin-*a* (Cophe) complex deionised with amberlite IR-120.

Table 4.19 Absorption band of cobalt(II) pheophytin-*a*

Peaks	Wavelength (nm)	Absorbance
1	431	1.293
2	656	0.719

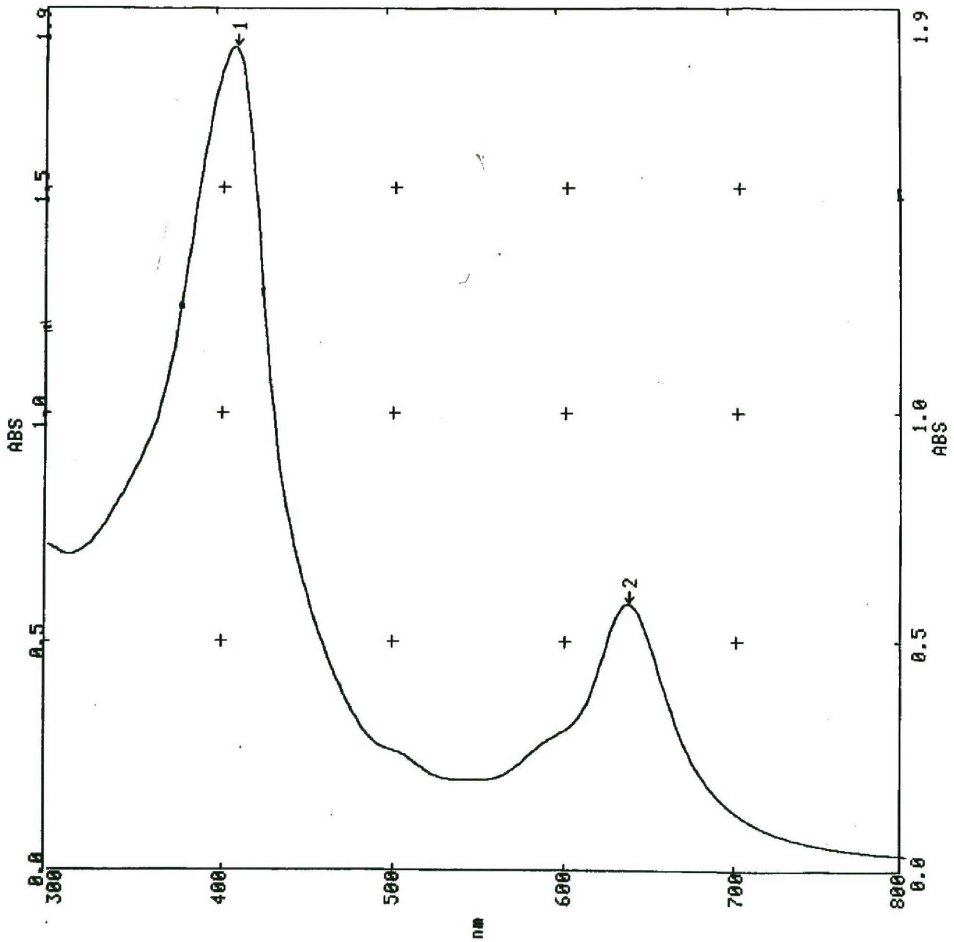


Figure 4.19 Absorption spectrum of chlorophillin coppered trisodium (Na_3Cuphe) salt in water.

Table 4.20 Absorption bands of coppered chlorophillin trisodium salt

Peaks	Wavelength (nm)	Absorbance
1	407	1.813
2	637	0.582

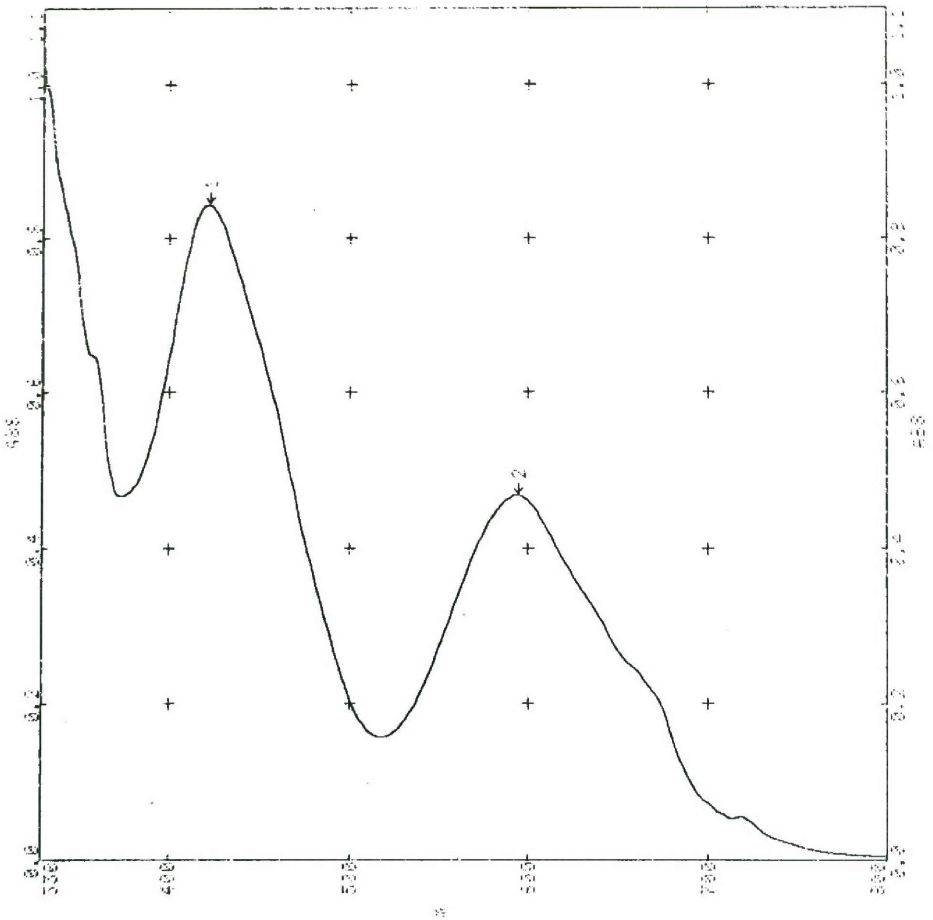


Figure 4.20 Absorption spectrum of Chromium(III) pheophytin-*a* (Crphe) complex deionised with amberlite IR-120.

Table 4.21 Absorption bands of chromium(III) pheophytin-*a*.

Peaks	Wavelength (nm)	Absorbance
1	422	0.843
2	594	0.465

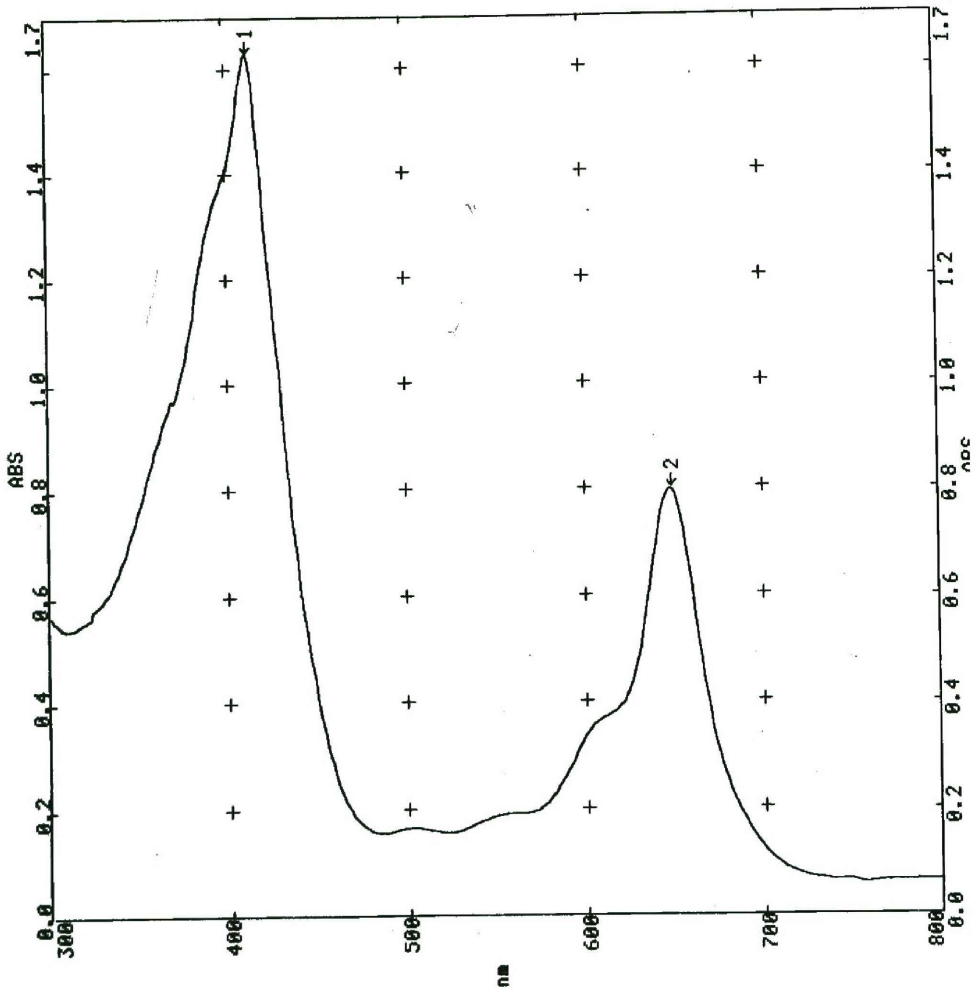


Figure 4.21 Absorption spectrum of Copper(II) pheophytin-*a* (Cuphe) complex deionised with amberlite IR-120.

Table 4.22 Absorption band of in copper(II) pheophytin-*a*.

Peaks	Wavelength (nm)	Absorbance
1	412	1.629
2	649	0.797

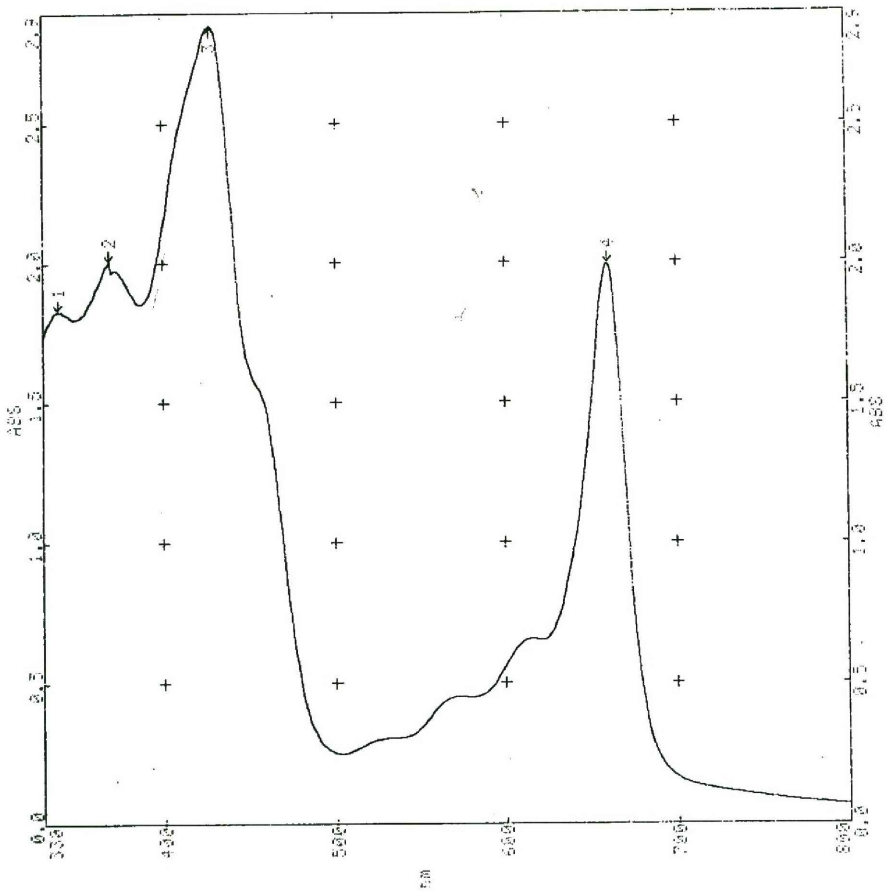


Figure 4.22 Absorption spectrum of Zinc pheophytin-*a* (Znphe) complex deionised with amberlite IR-120.

Table 4.23 Absorption bands of zinc pheophytin-*a*

Peaks	Wavelength (nm)	Absorbance
1	339	1.630
2	369	2.004
3	428	2.856
4	660	1.986

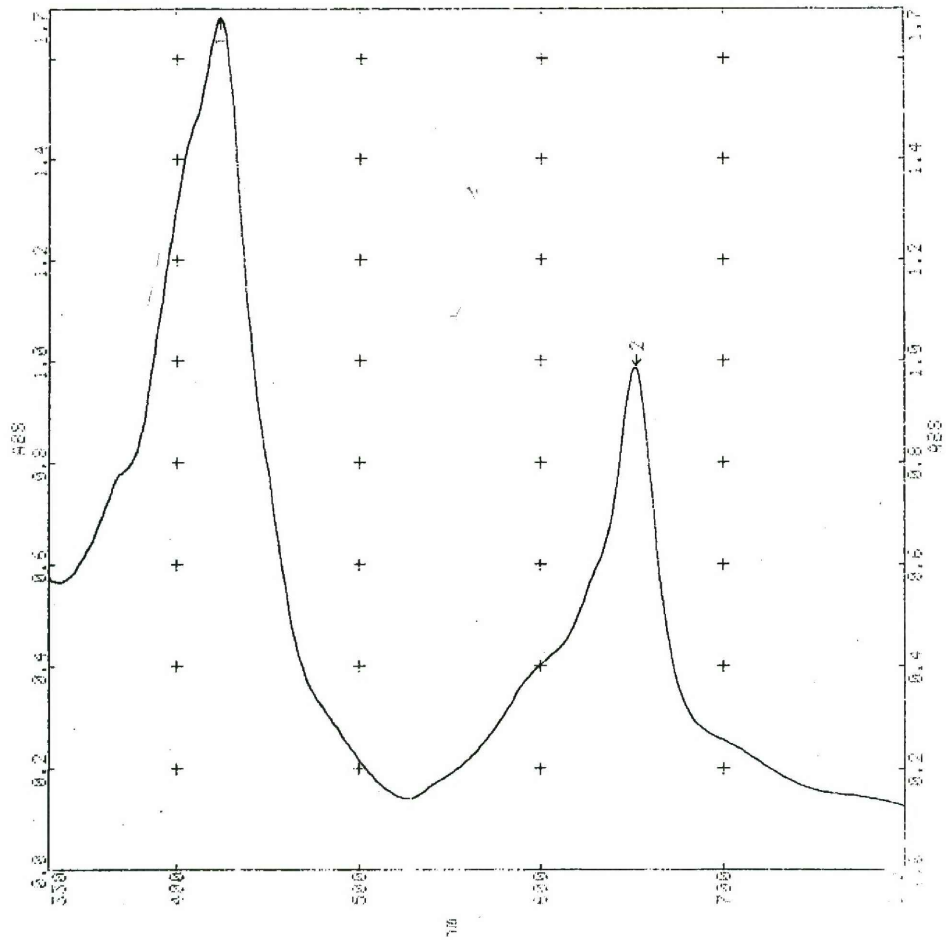


Figure 4.23 Absorption spectra of Nickel(II) pheophytin-*a* (Niphe) complex deionised with amberlite IR-120.

Table 4.24 Absorption bands of nickel(II) pheophytin-*a*

Peaks	Wavelength (nm)	Absorbance
1	423	1.682
2	652	0.935

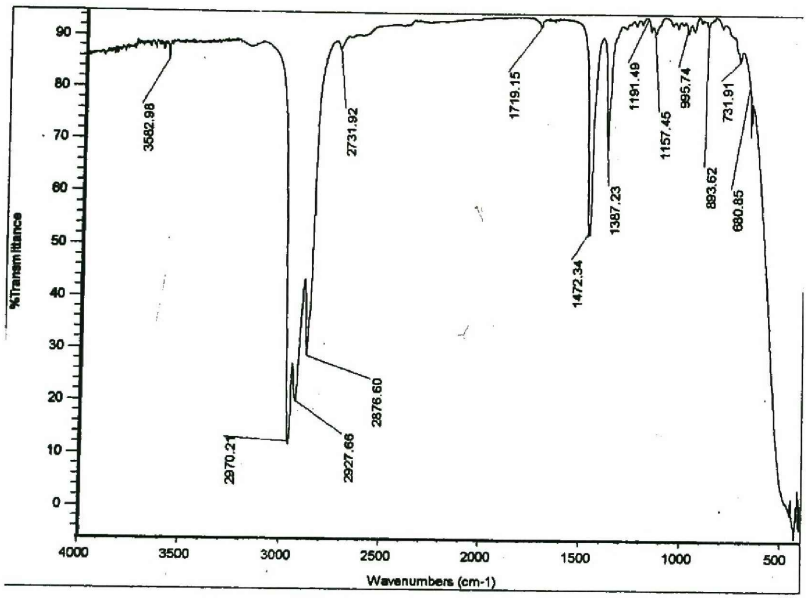


Figure 4.24 Infrared spectrum of chlorophyll-*a* in petroleum ether.

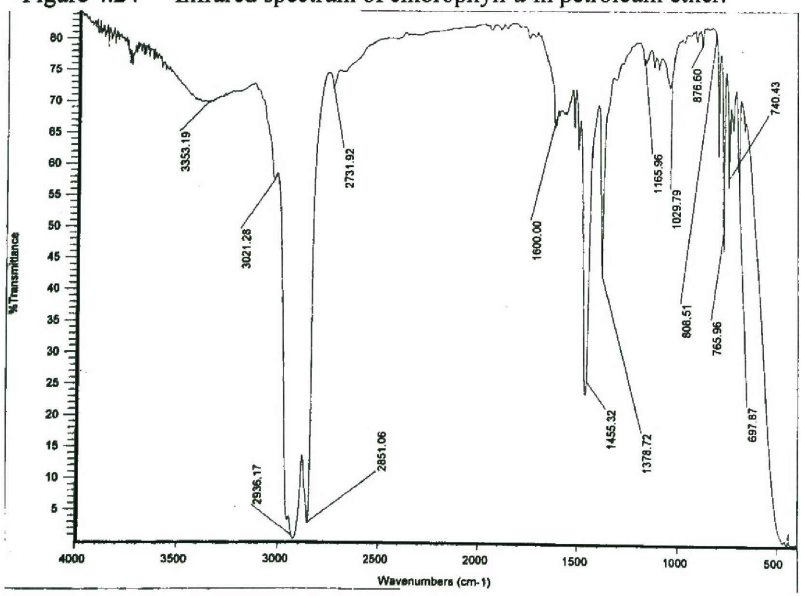


Figure 4.25 Infrared spectrum of chlorophyll-*a* in diethyl ether.

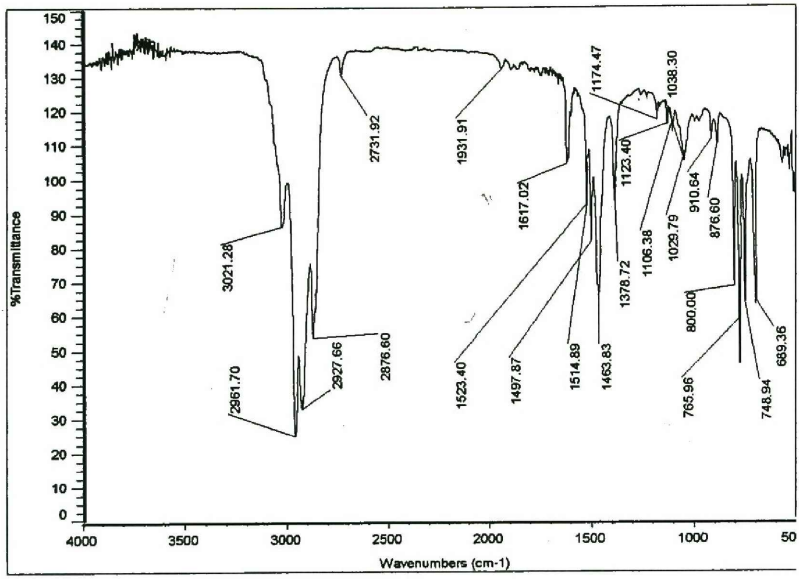


Figure 4.26 Infrared spectrum of pheophytin in petroleum ether without nujol.

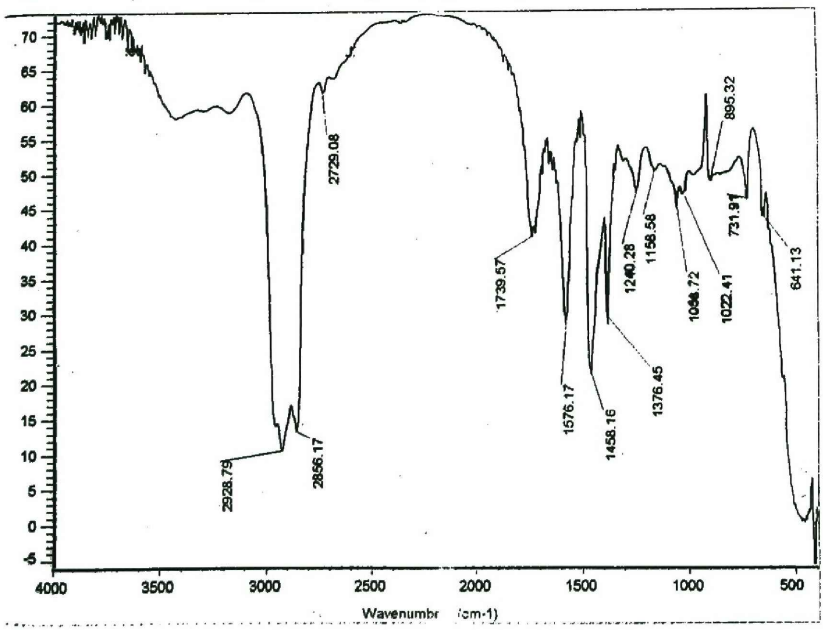


Figure 4.27 Infrared spectrum of cobalt(II) pheophytin-*a* complex.

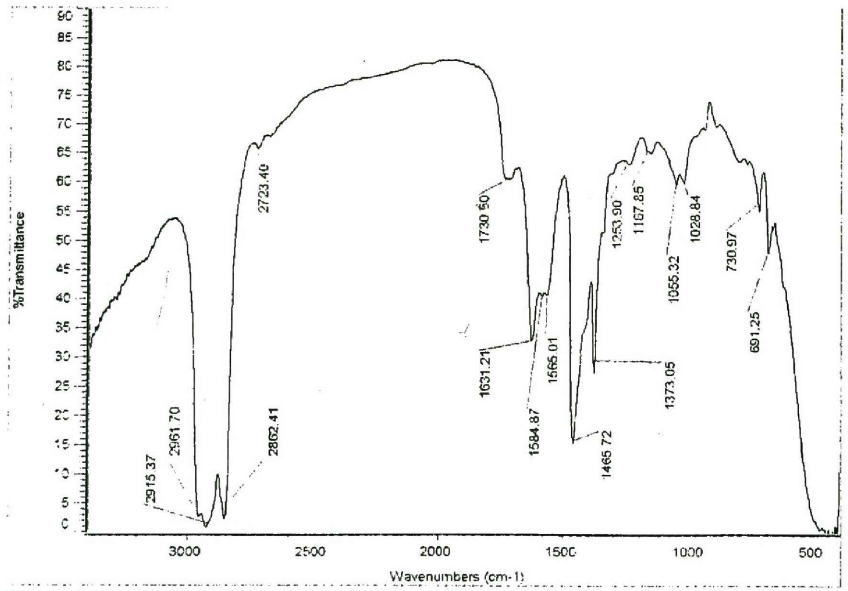


Figure 4.28 Infrared spectrum of copper(II) pheophytin-*a* complex

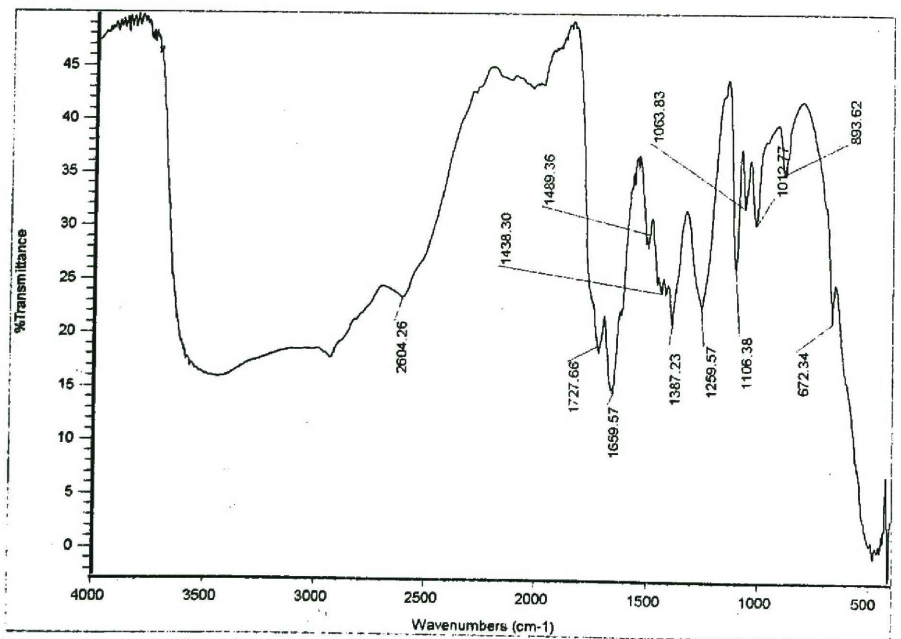


Figure 4.29 Infrared spectrum of chromium(III) pheophytin-*a* complex

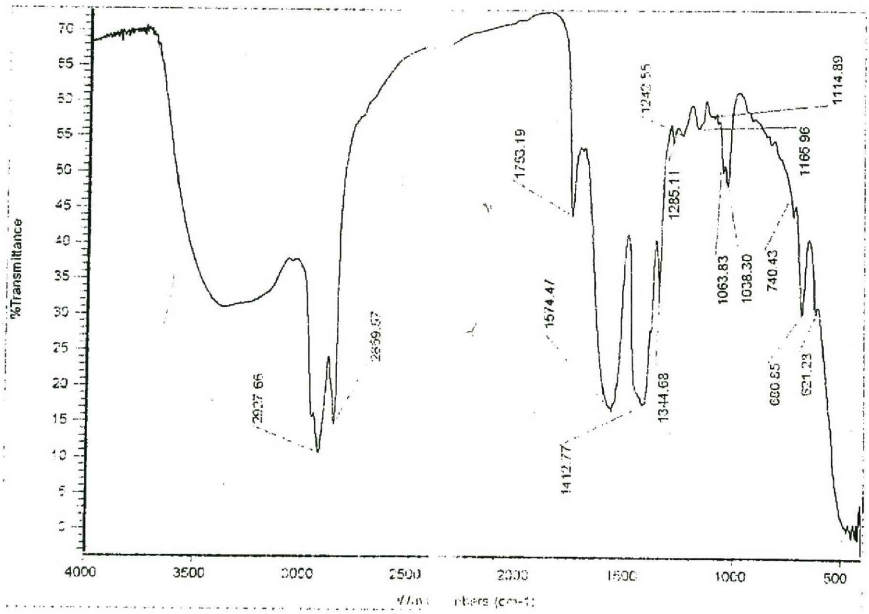


Figure 4.30 Infrared spectrum of nickel(II) pheophytin-*a* complex.

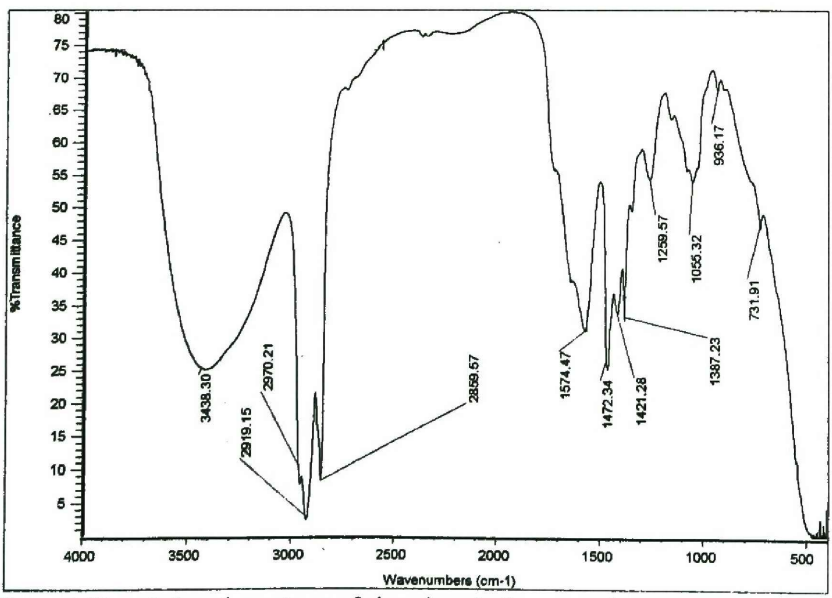


Figure 4.31 Infrared spectrum of zinc pheophytin-*a* complex

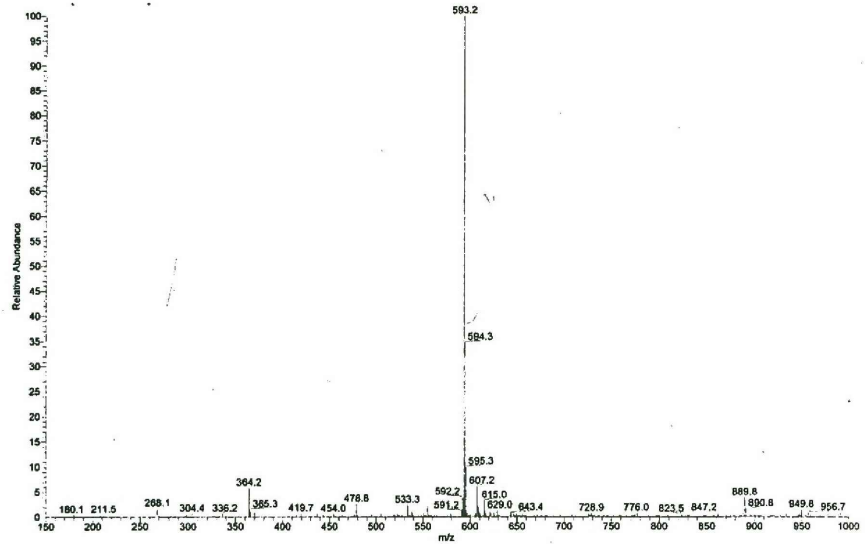


Figure 4.32 Electrospray ionization mass spectrum of pheophytin-*a* (*m/z* 150 – 1000)

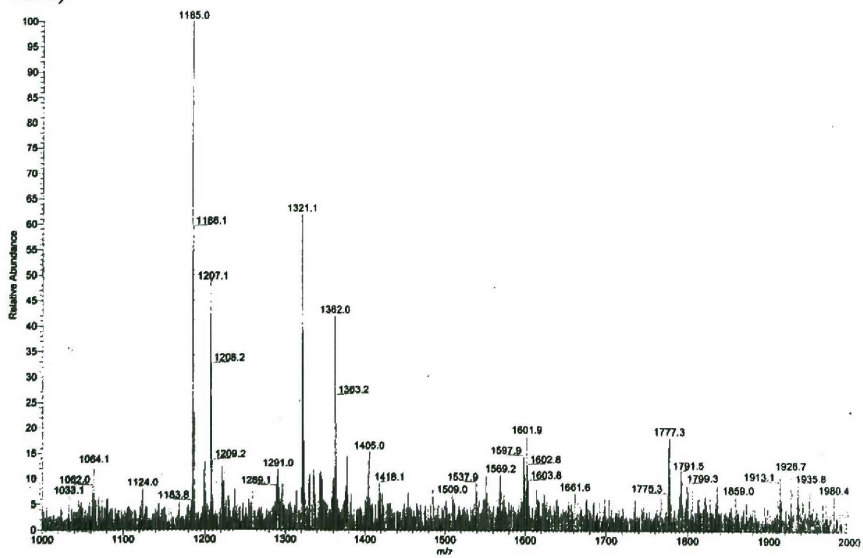


Figure 4.33 Electrospray ionization mass spectrum of pheophytin-*a* (*m/z* 1000 – 2000)

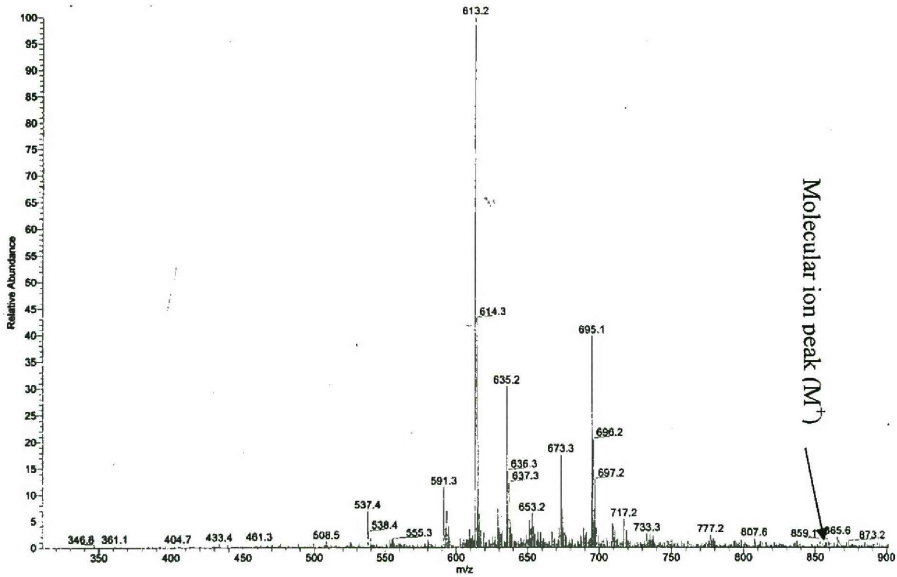


Figure 4.34 Electrospray ionization mass spectrum of chlorophyll-*a* (*m/z* 350 – 900)

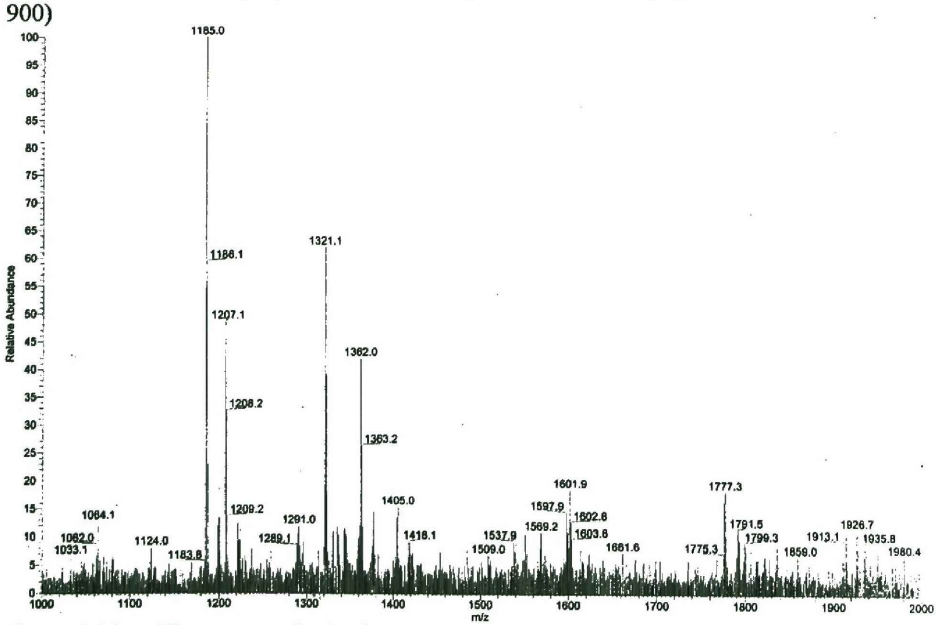


Figure 4.35 Electrospray ionization mass spectrum of chlorophyll-*a* (*m/z* 1000 – 2000)

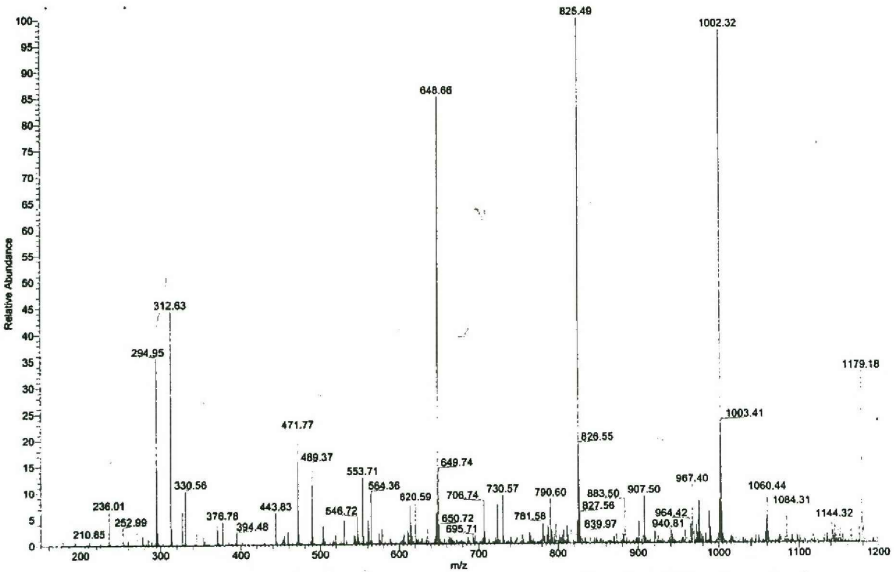


Figure 4.36 Electrospray ionization mass spectrum of cobalt(II) pheophytin-*a* complex. (*m/z* 200 – 1200)

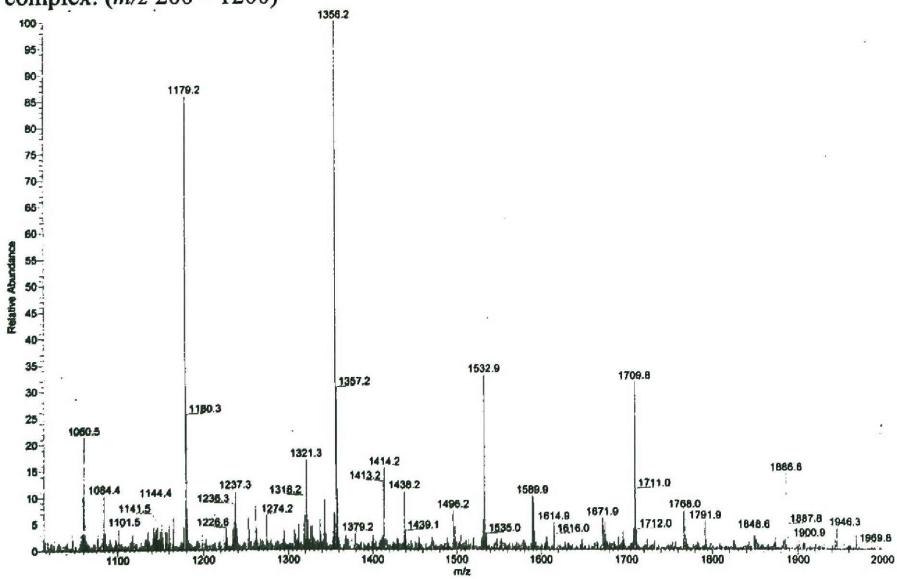


Figure 4.37 Electrospray ionization mass spectrum of cobalt(II) pheophytin-*a* complex. (*m/z* 1100 – 2000)

4.4 ELEMENTAL ANALYSES

Elemental analyses of the isolated metal pheophytin complexes (percentages of carbon, hydrogen and nitrogen in the various complexes) produced results that are in agreement with the formulations of the complexes.

The percentage composition of carbon, hydrogen and nitrogen in the various metal complexes are shown in Figures 4.38 – 4.42 and in Table 4.25.

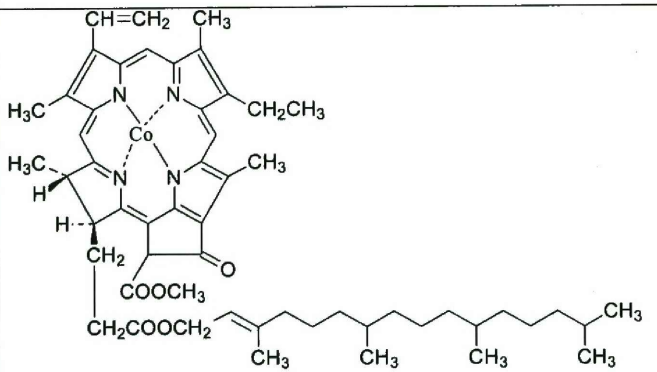
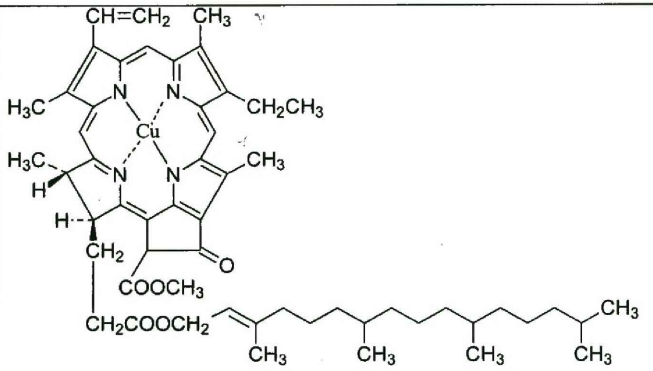
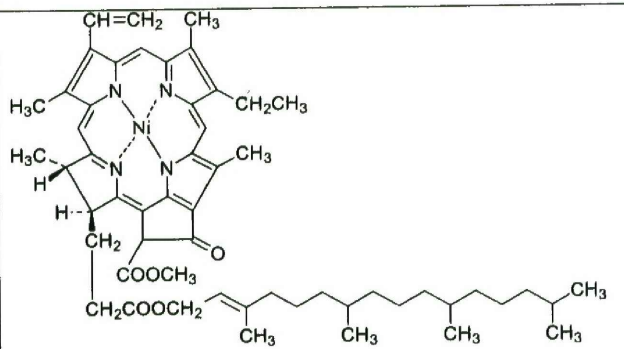
Name	Cobalt(II) pheophytin-*a* (Cophe)		
Formula	$C_{55}H_{72}N_4O_5Co$		
Relative Molecular Mass	928.13		
Structure			
ELEMENTAL ANALYSIS (%)			
	C	H	N
Found	70.93	7.98	5.90
Calculated	71.18	7.82	6.04

Figure 4.38 Elemental analysis of cobalt(II) pheophytin-*a* (Cophe)

Name	Copper(II) pheophytin-*a* (Cuphe)
Formula	$C_{55}H_{72}N_4O_5Cu$
Relative Molecular Mass	932.75
Structure	

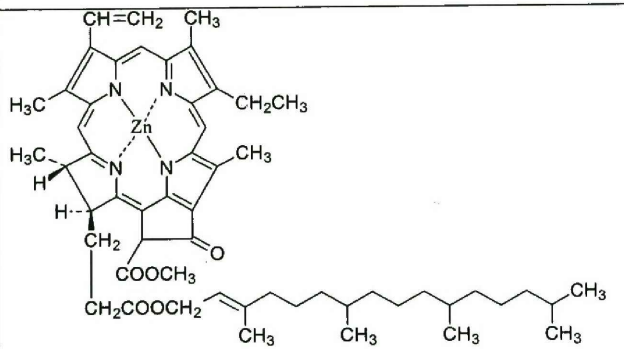
ELEMENTAL ANALYSIS (%)			
	C	H	N
Found	70.56	7.91	5.77
Calculated	70.82	7.78	6.01

Figure 4.39 Elemental analysis of copper(II) pheophytin-*a* (Cuphe)

Name	Nickel(II) pheophytin-*a* (Niphe)
Formula	$C_{55}H_{72}N_4O_5Ni$
Relative Molecular Mass	927.89
Structure	

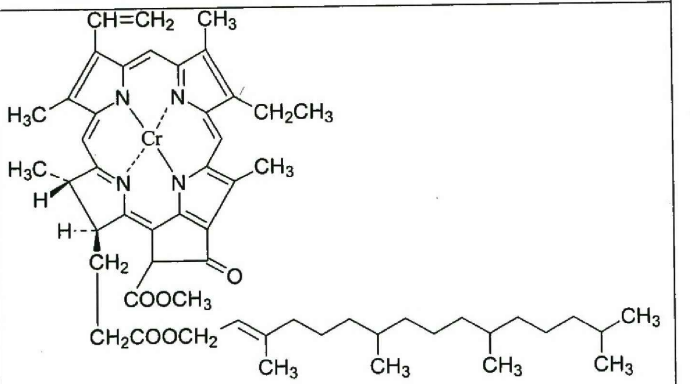
ELEMENTAL ANALYSIS (%)			
	C	H	N
Found	71.40	7.95	5.79
Calculated	71.19	7.82	6.04

Figure 4.40 Elemental analysis of nickel(II) pheophytin-*a* (Niphe)

Name	Zinc pheophytin-*a* (Znphe)
Formula	$C_{55}H_{72}N_4O_5Zn$
Relative Molecular Mass	934.58
Structure	

ELEMENTAL ANALYSIS (%)			
	C	H	N
Found	70.54	8.01	6.15
Calculated	70.68	7.77	5.99

Figure 4.41 Elemental analysis of zinc pheophytin-*a* (Znphe)

Name	Chromium(III) pheophytin-*a* (Crphe)
Formula	$C_{55}H_{72}N_4O_5Cr\ C\ell$
Relative Molecular Mass	956.70
Structure	

ELEMENTAL ANALYSIS (%)			
	C	H	N
Found	69.28	7.79	5.99
Calculated	69.05	7.60	5.86

Figure 4.42 Elemental analysis of chromium(II) pheophytin-*a* (Crphe)

Table 4.25 Summary of percentage composition by mass of carbon, hydrogen and nitrogen in metal pheophytin complexes.

Pheophytin Complex		**C (%)**	**H (%)**	**N (%)**
Cophe	Found Calculated	70.93 71.18	7.98 7.82	5.90 6.04
Cuphe	Found Calculated	70.56 70.82	7.91 7.78	5.77 6.01
Znphe	Found Calculated	70.54 70.68	8.01 7.77	6.15 5.99
Niphe	Found Calculated	71.40 71.19	7.95 7.82	5.79 6.04
[Crphe]Cℓ	Found Calculated	69.28 69.05	7.79 7.60	5.99 5.86

4.5 KINETICS OF OXIDATION OF COBALT(II) PHEOPHYTIN-*a* BY HEXAAQUACHROMIUM(III) CATION

Preliminary repetitive scanning of the ultraviolet-visible spectral region during oxidation of the cobalt(II) pheophytin-*a* complex (Cophe) by hexaaquachromium(III) cation, ($[Cr(H_2O)_6]^{3+}$) in 0.1 mol/dm^3 hydrochloric acid solution gave well-defined isosbestic points at 323, 442.3, 519.2 and 608.8 nm for more than 2 half-lives of the reaction. The spectral changes at different temperatures are shown in Figures 4.43 - 4.45.

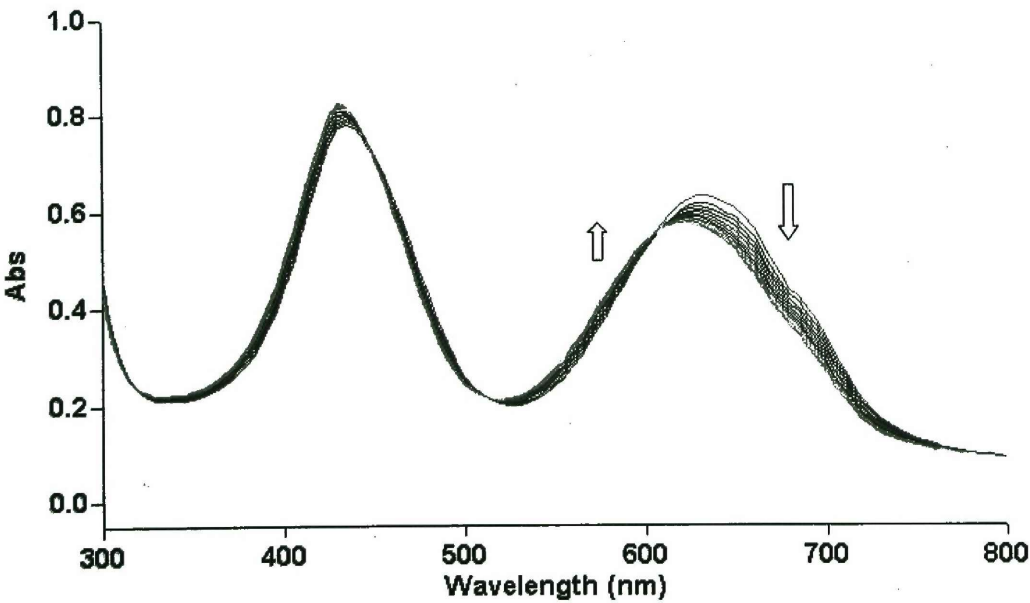


Figure 4.43 Spectral changes during the reaction of Cophe and ($[Cr(H_2O)_6]^{3+}$) in (0.1 mol/dm^3) hydrochloric acid solution at 5-minute intervals and at 313 K.

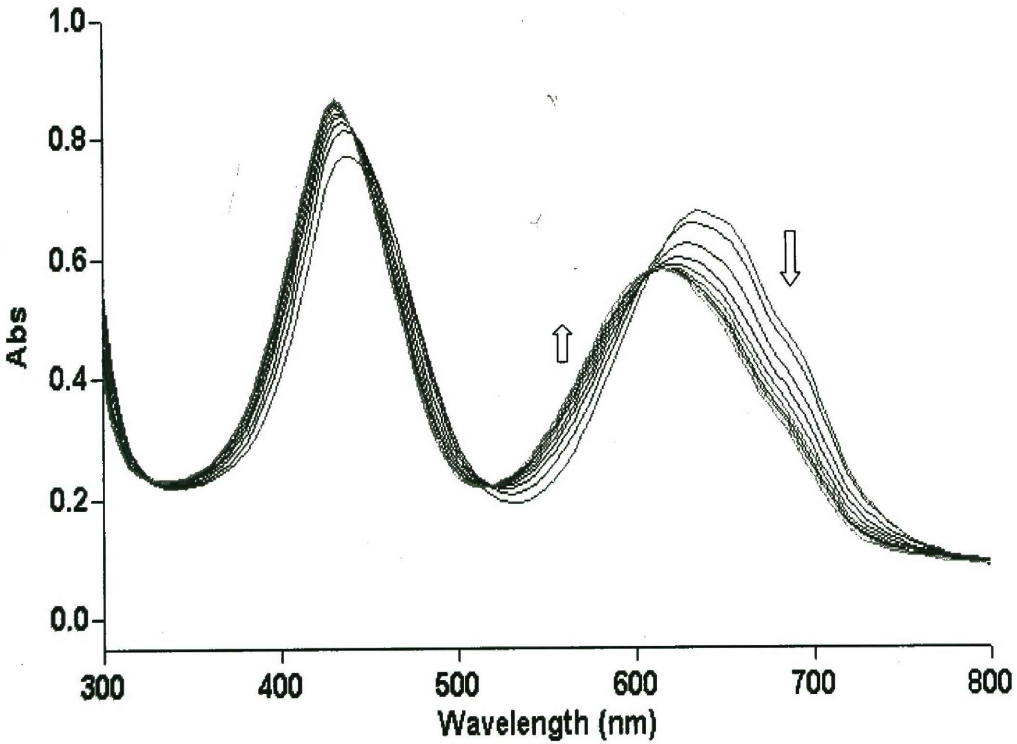


Figure 4.44 Spectral changes during the reaction of Cophe and ($[Cr(H_2O)_6]^{3+}$) in (0.1 mol/dm^3) hydrochloric acid solution at 10-minute intervals and at 323 K

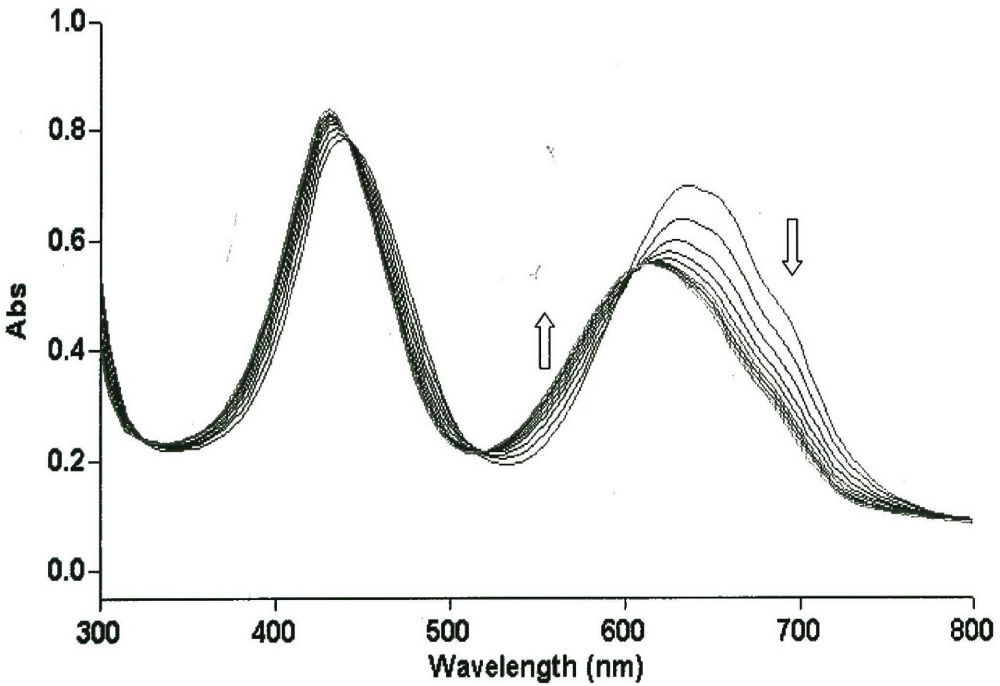


Figure 4.45 Spectral changes during the reaction of Cophe and ($[Cr(H_2O)_6]^{3+}$) in (0.1 mol/dm^3) hydrochloric acid solution at 20-minute intervals and at 333 K

The kinetics of the oxidation of cobalt(II) pheophytin-*a* was then followed at a fixed wavelength (630 nm) and the first order rate constants were obtained from plots of

$\ln[(A_t - A_\infty)/(A_0 - A_\infty)]$ versus time in minutes.

A_t = Absorbance at time t

A_0 = Absorbance at initial time

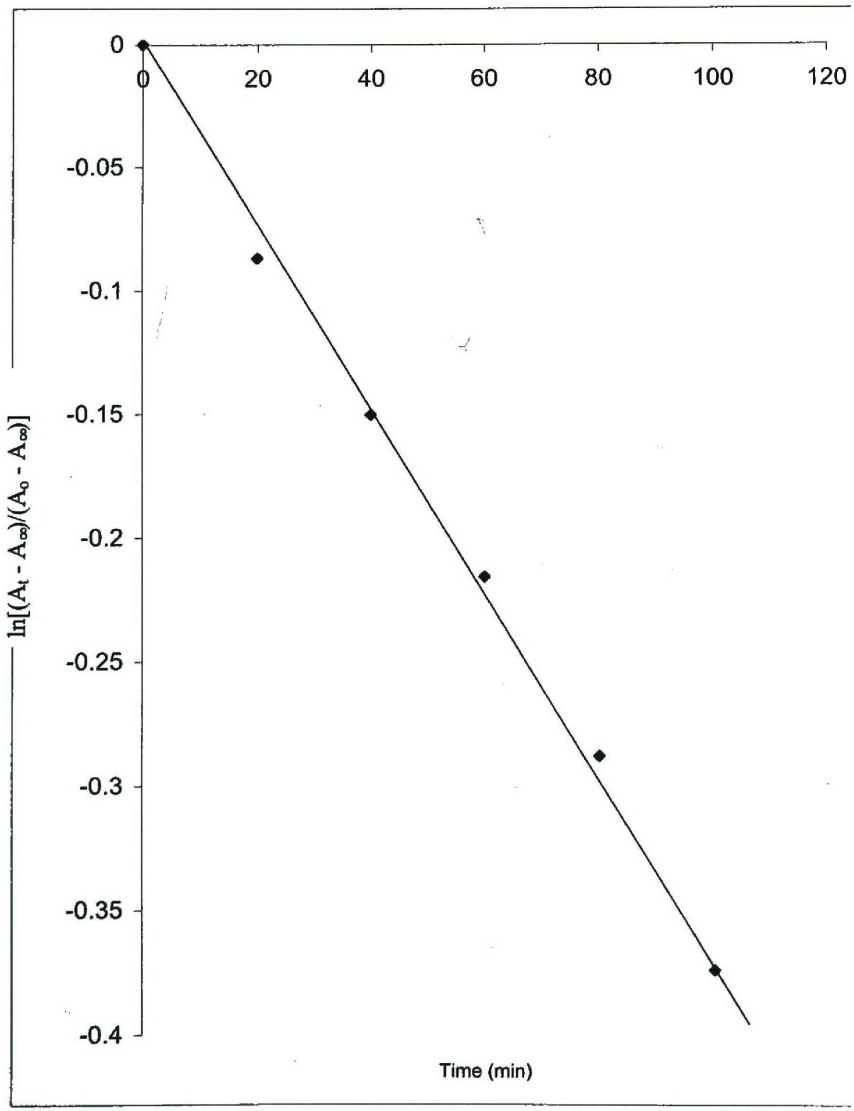
A_∞ = Absorbance at infinity

4.5.1 THE OXIDATION OF COBALT(II) PHEOPHYTIN-*a* BY HEXAAQUACHROMIUM(III) CATION AT 313 K

The kinetics of the oxidation of cobalt(II) pheophytin-*a* (Cophe: 6.45 x 10^{-5} mol/dm^3) with hexaaquachromium(III) cation ($([Cr(H_2O)_6]^{3+}$): 0.01 mol/dm^3) in hydrochloric acid (0.1 mol/dm^3) solution was then followed at a fixed wavelength of 630 nm, where the largest change in absorption was observed. Kinetic plots at 313 K are displayed in Figures 4.50 and 4.51.

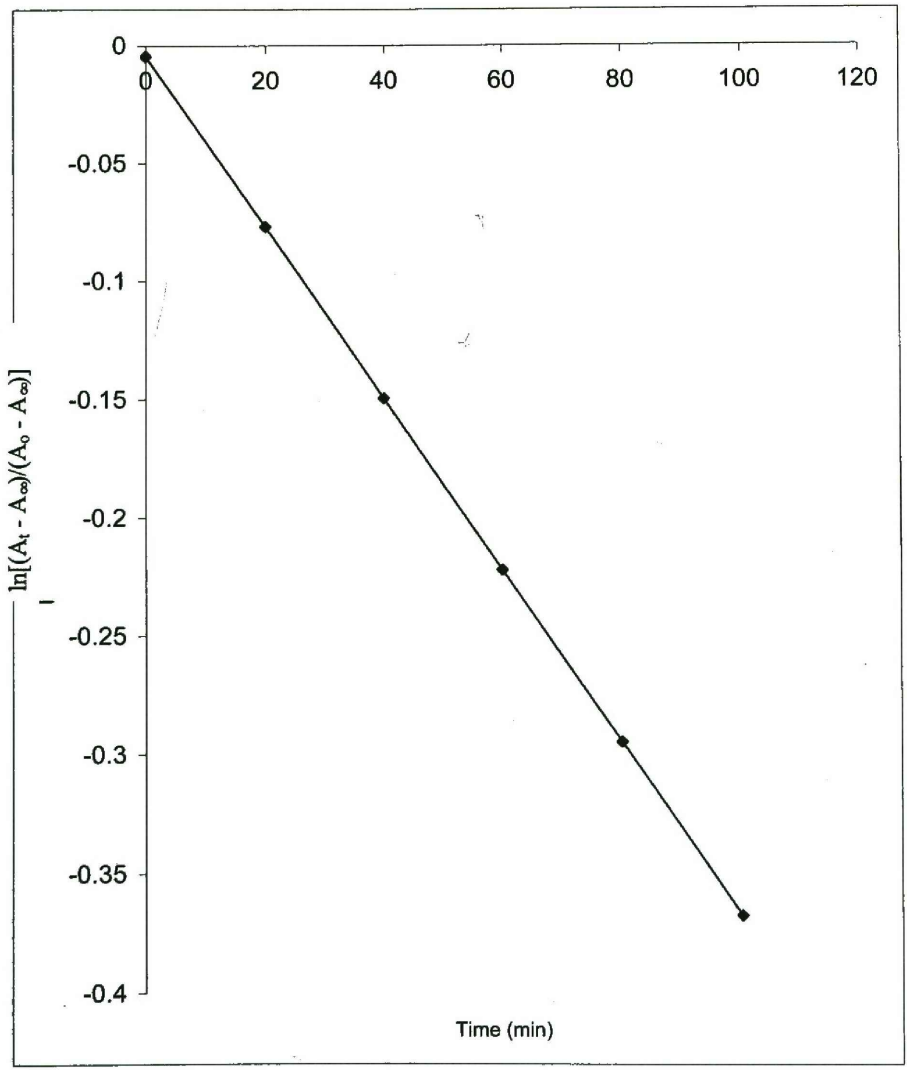
Table 4.26 Kinetic results for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation.

Time (minutes)	**Absorbance**	$(A_t-A_\infty)/(A_0-A_\infty)$	$\ln[(A_t-A_\infty)/(A_0-A_\infty)]$	Least square plot
0	0.5959	1	0	-0.00456
20	0.5715	0.916724	-0.08695	-0.07716
40	0.555	0.86041	-0.15035	-0.14976
60	0.539	0.805802	-0.21592	-0.22236
80	0.5226	0.749829	-0.28791	-0.29496
100	0.5045	0.688055	-0.37389	-0.36756



Rate constant = 5.4 x 10^{-5} s^{-1}

Figure 4.46 A typical plot of the oxidation of cobalt(II) pheophytin-*a* [6.45 x 10^{-5} mol/dm^3] by hexaaquachromium(III) cation at 313 K



Rate constant = 6.1×10^{-5} s^{-1}

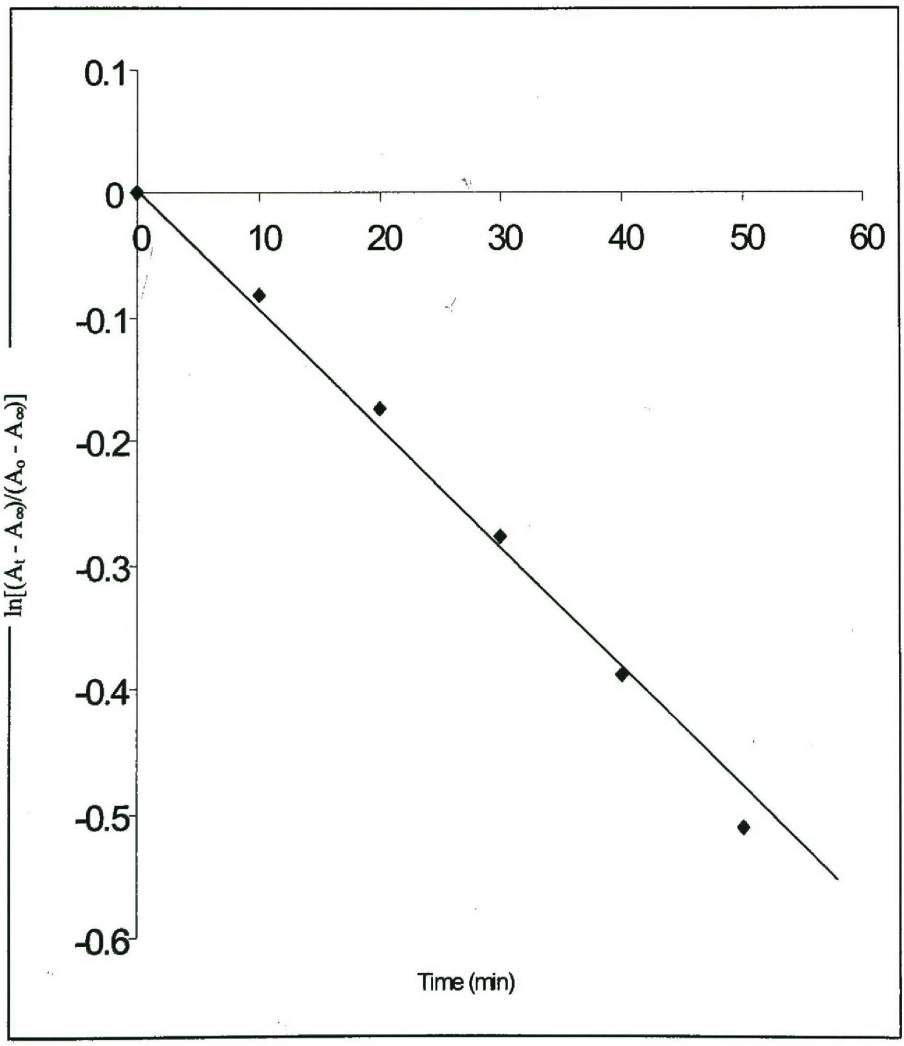
Figure 4.47 Least squares[141] kinetic plot for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation at 313 K

4.5.2 THE OXIDATION OF COBALT(II) PHEOPHYTIN-*a* BY HEXAAQUACHROMIUM(III) CATION AT 323 K

The Kinetics of the oxidation of cobalt(II) pheophytin-*a* (Cophe: 6.45 x 10^{-5} mol/dm^3) with hexaaquachromium(III) cation ($([Cr(H_2O)_6]^{3+}$): 0.01 mol/dm^3) in hydrochloric acid (0.1 mol/dm^3) solution was then followed at a wavelength of 630 nm. Kinetic plots at 323 K are displayed in Figures 4.48 and 4.49.

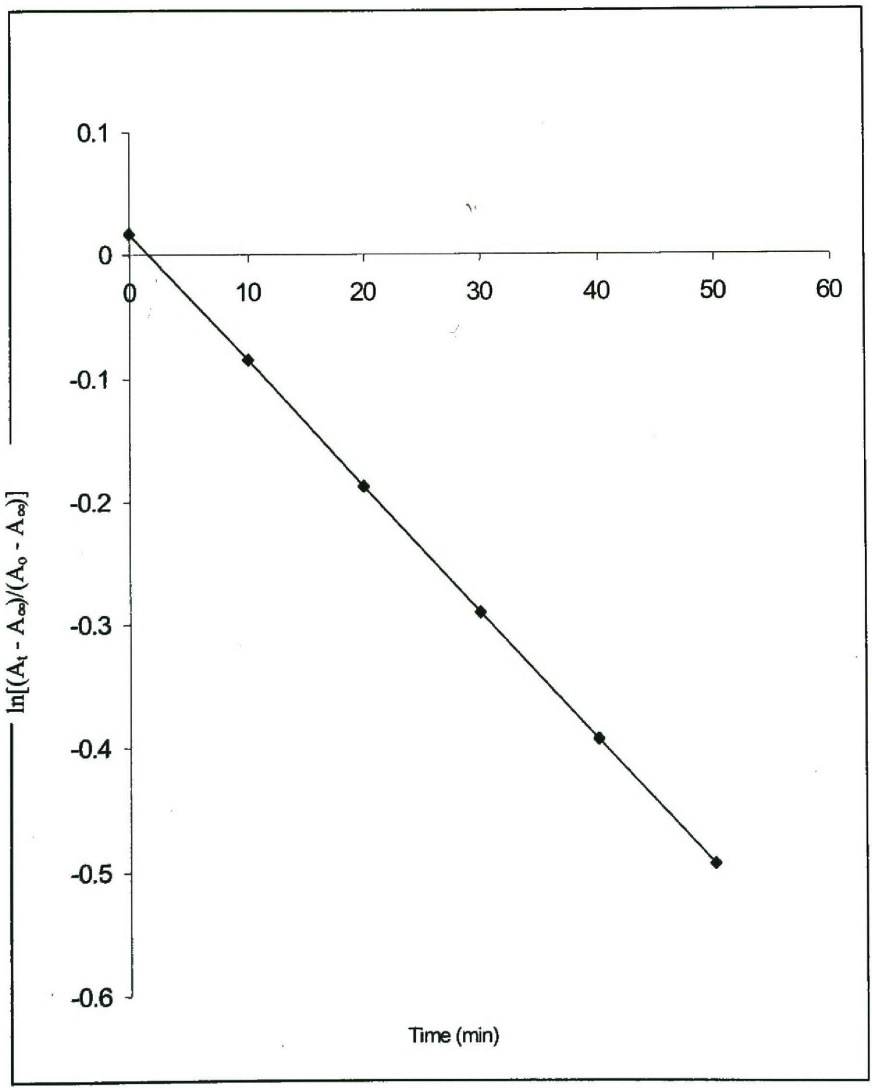
Table 4.27 Kinetic results for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation at 323 K

Time (minutes)	**Absorbance**	$(A_t-A_\infty)/(A_o-A_\infty)$	$\ln[(A_t-A_\infty)/(A_o-A_\infty)]$	Least squares plot
0	0.678	1	0	0.017128
10	0.6486	0.921621	-0.08162	-0.08527
20	0.6181	0.840309	-0.17399	-0.18767
30	0.5873	0.758198	-0.27681	-0.29007
40	0.5573	0.678219	-0.38828	-0.39247
50	0.5277	0.599307	-0.51198	-0.49487



Rate constant = 1.8×10^{-4} s^{-1}

Figure 4.48 A typical plot of the oxidation of cobalt(II) pheophytin-*a* [6.45×10^{-5} mol/dm^3] by hexaaquachromium(III) cation at 323 K



Rate constant = 1.7×10^{-4} s^{-1}

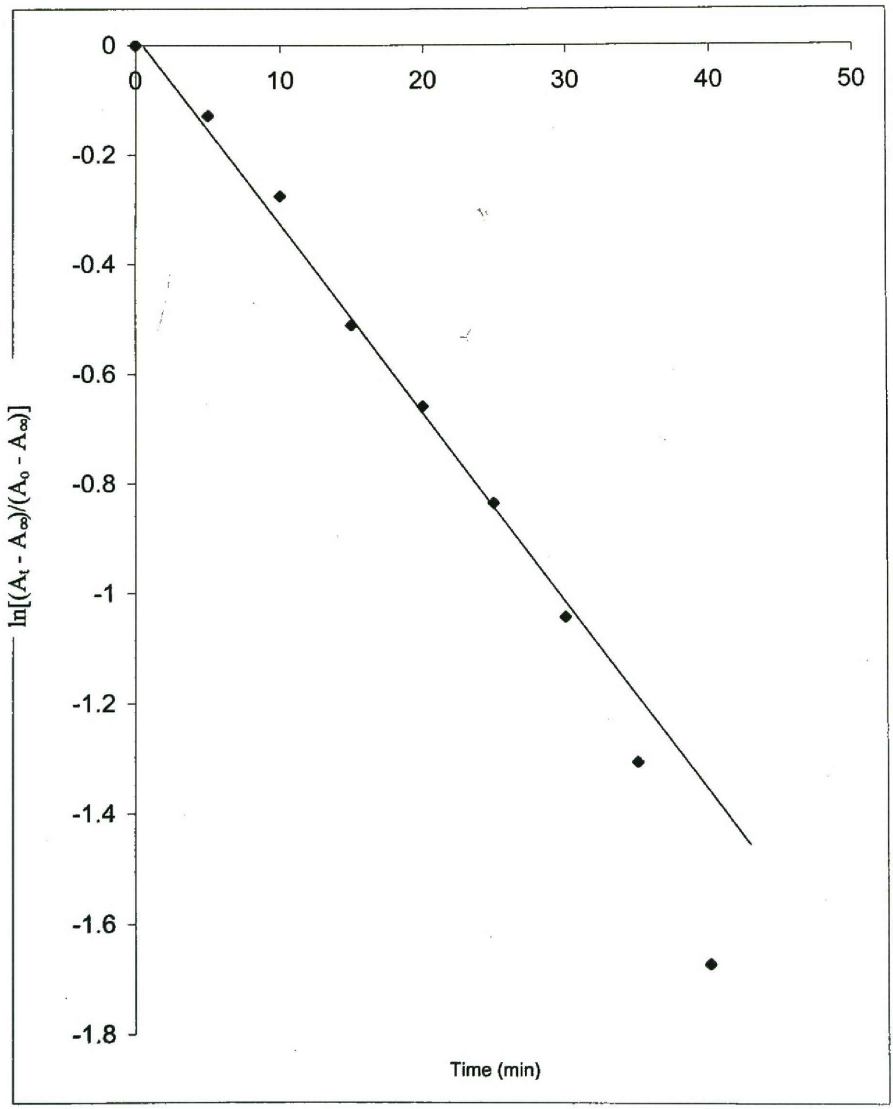
Figure 4.49 Least squares kinetic plot for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation at 323 K

4.5.3 THE OXIDATION OF COBALT(II) PHEOPHYTIN-*a* BY HEXAAQUACHROMIUM(III) CATION AT 333 K

Kinetics of the oxidation of cobalt(II) pheophytin-*a* (Cophe: 6.45 x 10^{-5} mol/dm^3) with hexaaquachromium(III) cation ($[Cr(H_2O)_6]^{3+}$): 0.01 mol/dm^3) in hydrochloric acid (0.1 mol/dm^3) solution was then followed at a wavelength of 630 nm. Kinetic plots at 333 K are displayed in Figures 4.50 and 4.51.

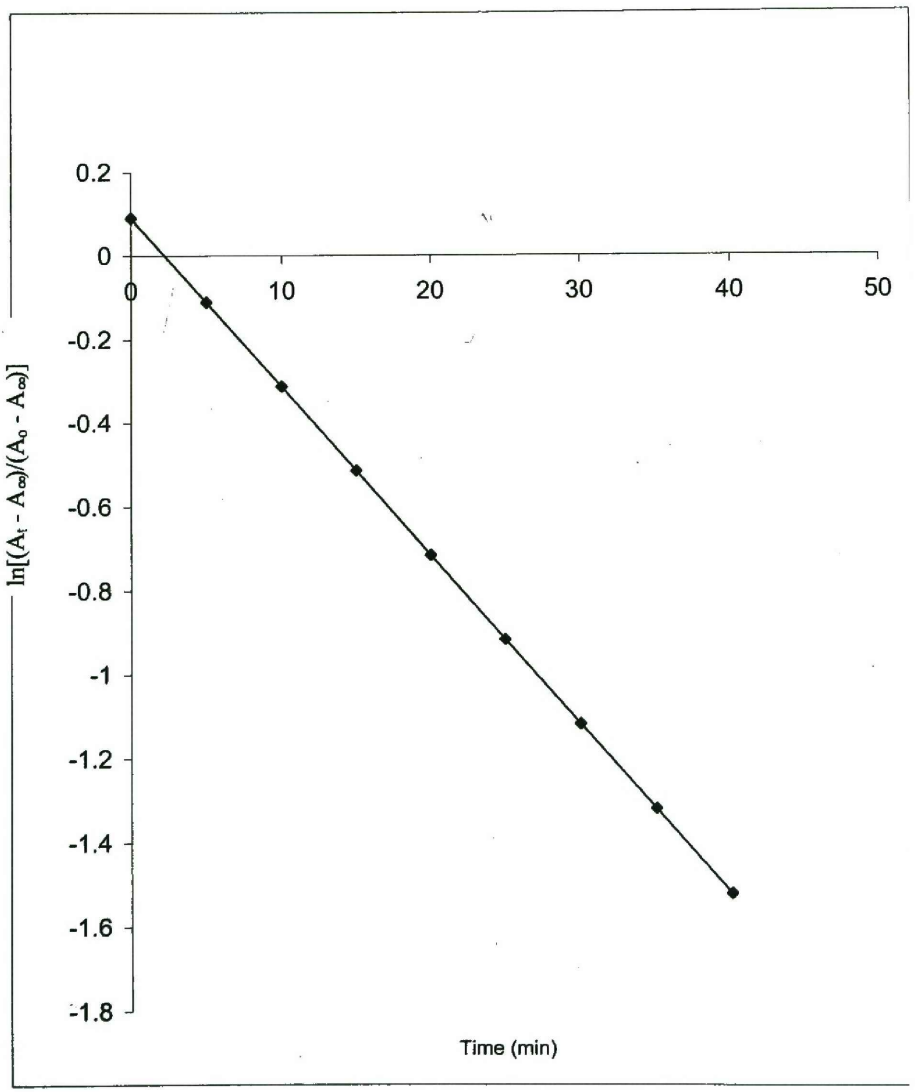
Table 4.28 Kinetic results for the reaction of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation.

Time (minutes)	**Absorbance**	$(A_t-A_\infty)/(A_o-A_\infty)$	$\ln[(A_t-A_\infty)/(A_o-A_\infty)]$	Least Squares
0	0.7333	1	-1.1E-16	0.090306
5	0.6813	0.879182	-0.12876	-0.11114
10	0.6293	0.758364	-0.27659	-0.31259
15	0.5607	0.598978	-0.51253	-0.51404
20	0.5253	0.516729	-0.66024	-0.71549
25	0.4893	0.433086	-0.83682	-0.91694
30	0.4544	0.351998	-1.04413	-1.11839
35	0.4193	0.270446	-1.30768	-1.31984
40	0.3837	0.187732	-1.67274	-1.52129



Rate constant = 5.9×10^{-4} s^{-1}

Figure 4.50 A typical plot of the oxidation of cobalt(II) pheophytin-*a* [6.45×10^{-5} mol/dm^3] by hexaaquachromium(III) cation at 333 K



Rate constant = 6.7×10^{-4} s^{-1}

Figure 4.51 Least squares kinetic plot for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation at 333 K

First order rate constants for the oxidation of cobalt(II) pheophytin-*a* (Cophe) by hexaaquachromium(III) cation ($[Cr(H_2O)_6]^{3+}$) at different temperatures.

Table 4.29 Table of calculated and best–fit (least squares) rate constants at different temperatures for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation.

Temperature (K)	**Rate Constant (s^{-1})**	**Least Square Rate Constant (s^{-1})**
313	5.4×10^{-5}	6.1×10^{-5}
313	7.9×10^{-5}	7.0×10^{-5}
323	1.8×10^{-4}	1.7×10^{-4}
323	1.7×10^{-4}	1.7×10^{-4}
323	1.8×10^{-4}	1.7×10^{-4}
333	5.9×10^{-4}	6.7×10^{-4}
333	5.2×10^{-4}	6.6×10^{-4}

4.5.4 ARRHENIUS PARAMETERS

Table 4.30 Kinetic results for the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation.

Temperature (K)	Rate Constant (s^{-1})	$\frac{1}{T}$ (K)	ln K
313	5.4×10^{-5}	3.2×10^{-3}	-9.83
323	1.8×10^{-4}	3.1×10^{-3}	-8.62
333	5.9×10^{-4}	3.0×10^{-3}	-7.44

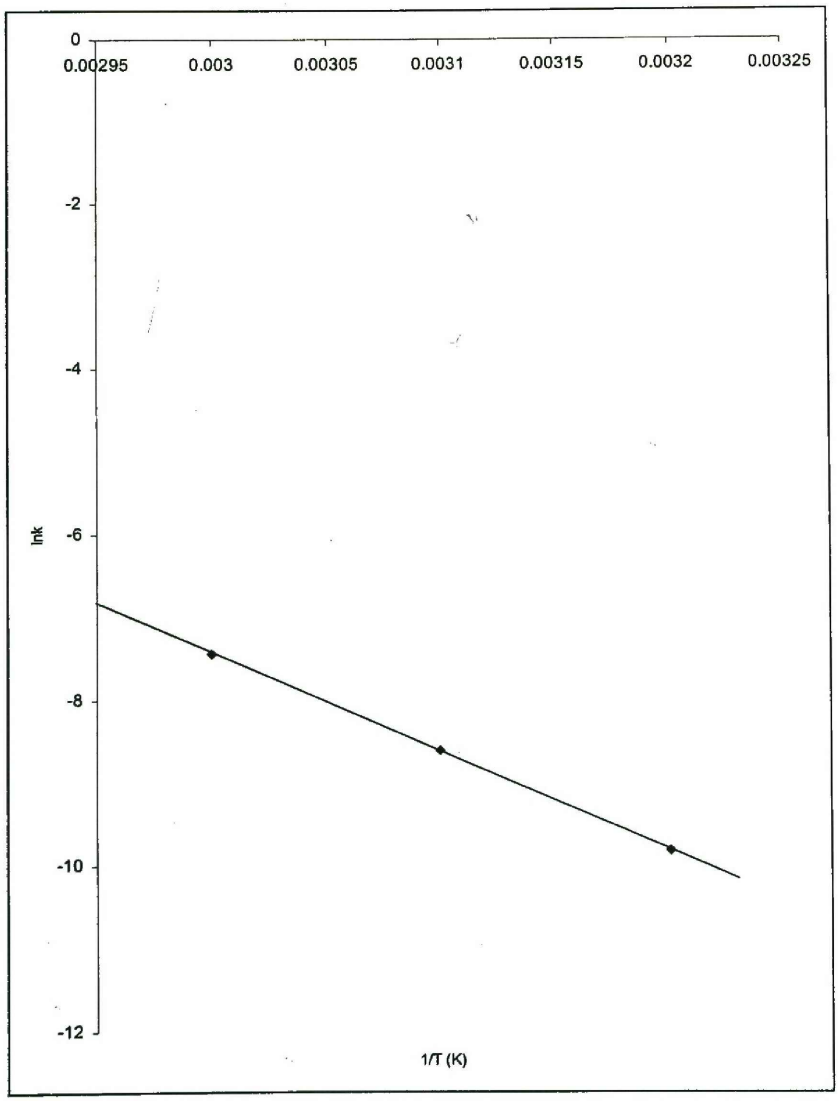


Figure 4.52 Temperature dependence of the first-order rate constant for the oxidation of Cophe by ($[Cr(H_2O)_6]^{3+}$)

Slope = -11950 K

E_a = -8.314 J ~~K~~$^{-1}$ mol^{-1} x -11950 ~~K~~

E_a = 99352.3 J mol^{-1}

E_a = 99.35 kJmol^{-1}

From the equation

$$\ln A = \ln k + \frac{E_a}{RT}$$

At 40°C (313 K)

$$\ln A = -9.83 + \frac{99.35kJ/mol}{8.314J/Kmolx313K}$$

ln A = -9.79 s^{-1}

A = 5.6 x 10^{-5} s^{-1}

CHAPTER FIVE

DISCUSSION

5.1 EXTRACTION

Several methods[10,59] of extraction of chlorophyll-*a* were employed and found unsatisfactory. These methods (alumina column method and silica gel column method) produced "chlorophyll-*a*" with absorption bands different from those observed by other researchers.[1,3,140] In addition, the amount of chlorophyll-*a* in the final extract was significantly low, indicating the presence of impurities. In an attempt to address the shortcomings of these methods, the silica gel method was modified to improve the quality and quantity of chlorophyll-*a* extracted.

5.1.1 THE ALUMINA COLUMN METHOD (METHOD 1)

The extract chromatographed on an alumina stationary phase with toluene and a mixture of *n*-butanol, ethanol and water (3:1:1 v/v) as mobile phases was unsuccessful. This was in contrast to research reports[59] of the use of alumina and toluene as stationary and mobile phases, respectively.

This procedure was unsatisfactory in the light of the shape of the absorption bands in the ultraviolet-visible spectra and concentrations of chlorophyll-*a* and pheophytin-*a* obtained at the end of the chromatographic separation [Figures 4.1 and 4.3; Tables 4.1(b) and 4.3(b)].

The concentration of total chlorophyll obtained from this chromatographic separation was 2.013 mg/L, which is relatively low. The low amount of chlorophyll-*a* and pheophytin-*a* obtained here indicates that there is a large amount of carotene, xanthophylls and other chlorophyll degradation products in the extract.

The extraction procedure employed in this method is shown in Figure 5.1.

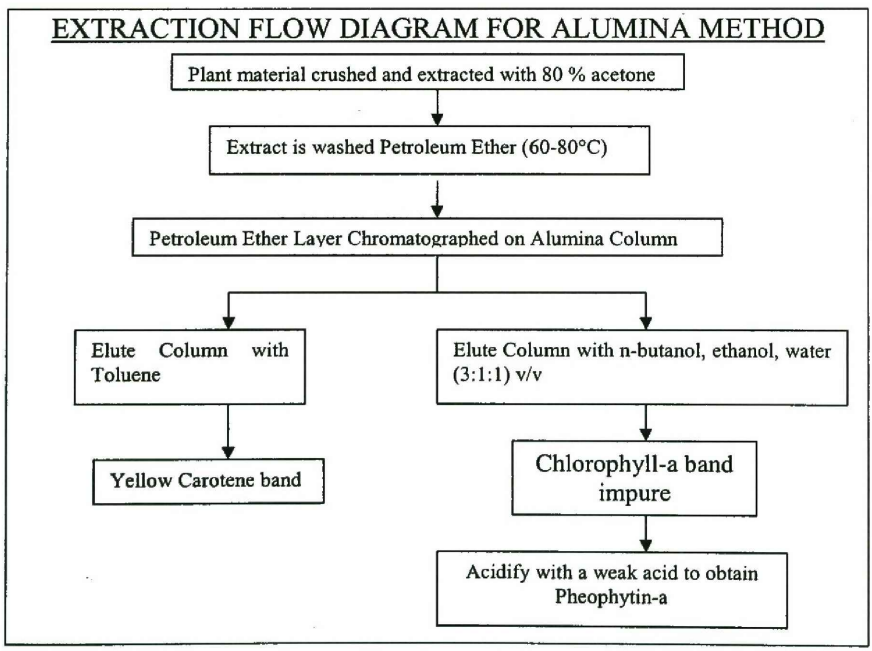


Figure 5.1 Extraction of chlorophyll using alumina column method (method 1)

5.1.2 SILICA GEL COLUMN METHOD (METHOD 2)

Silica gel was used as the stationary phase instead of alumina with toluene and *n*-butanol, ethanol and water (3:1:1 v/v) as mobile phases. This change resulted in absorption spectra with band shapes similar to those obtained in the alumina method, (Figures 4.3 and 4.4).

As in the case of the alumina column, this procedure was unsatisfactory in the light of the shape of the absorption bands in the ultraviolet-visible spectra and concentration of chlorophyll-*a* and pheophytin-*a* obtained at the end of the chromatographic separation. Figure 4.4, 4.6 and Table 4.4(b).

The concentration of total chlorophyll obtained in this chromatographic separation improved to 14.529 mg/L. However, the shape of the absorption bands in the ultraviolet-visible spectra is different to that reported in the literature.[3,12,140] The chlorophyll-*a* extract in the solvent system [*n*-butanol, ethanol and water (3:1:1 v/v)], was acidified with glacial acetic acid to give pheophytin-*a* in the expected colour, but could not be crystallized.

The extraction procedure employed in this method is summarized in the flow diagram shown in Figure 5.2.

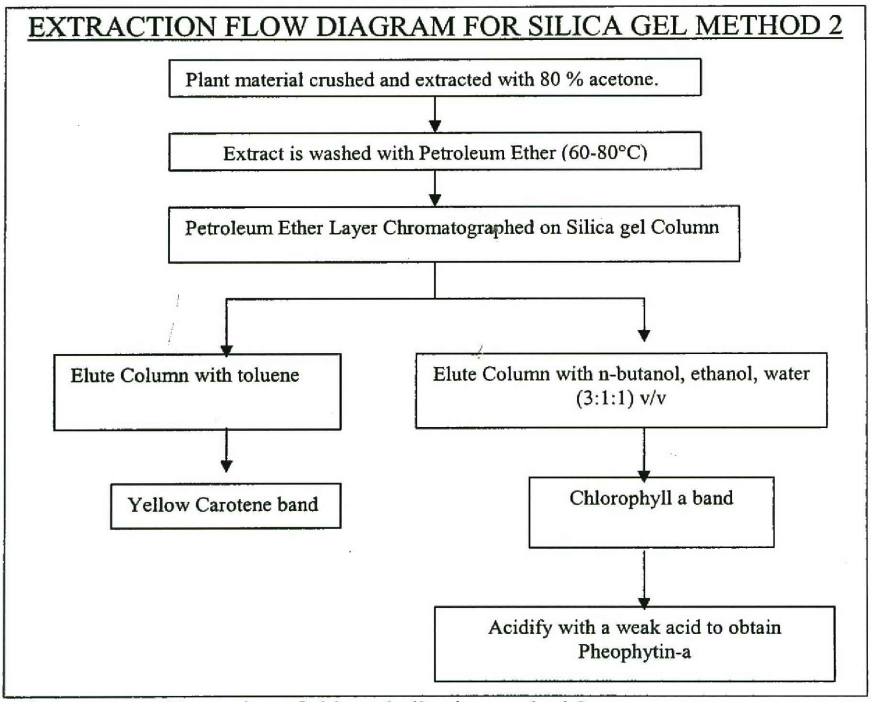


Figure 5.2 Extraction of chlorophyll using method 2

5.1.3 IMPROVED SILICA GEL COLUMN METHOD (METHOD 3)

Extraction of chlorophyll using the silica gel column method (Figure 5.2) was modified. This was because the shapes of the visible absorption bands of chlorophyll-*a* obtained from the previous methods (alumina method and silica gel method) were different from those reported in the literature.[3,12,59] The quantities of chlorophyll-*a* and pheophytin-*a* from the aforementioned methods of extraction were also significantly low compared to literature reports.

An improved silica gel column method was therefore developed and used.

In this modified silica gel column method, shown in Figure 5.3, the chlorophyll extract in the acetone was washed several times with petroleum ether and petroleum ether was used as the first mobile phase in the chromatographic column to elute carotene and carotenoids. A second mobile phase of petroleum ether and *n*-propanol was then used to elute chlorophyll-*a*.

The improvement in the extraction was such that the amount of total chlorophyll obtained in this modified method (27.005 mg/L) was higher than those obtained from the alumina column and the silica gel column (2.013 mg/L and 14.529 mg/L, respectively). The shape of the absorption bands and the wavelengths of absorption in this improved method (Figure 4.16) was in agreement with that obtained in literature reports.[3,12,19,140]

The advantage of this method in comparison to the other methods was that a liquid-liquid extraction procedure was used to obtain a good yield of chlorophyll. Due to several washings with petroleum ether and eluting the column with petroleum ether rather than with *n*-butanol, ethanol and water (3:1:1 v/v), carotenes, xanthophylls and other chlorophyll degradation products were greatly reduced.

Washing the methanol layer with petroleum ether several times helped to recover any chlorophyll that would otherwise have been lost. Washing the acetone layer and methanol layer with petroleum ether before chromatography, reduced the amount of carotene associated with the chlorophyll.

Carotenoids have been found[8,41,47,90,105,106] to mask the chlorophyll visible absorption spectra. Wilson and coworkers[104] used tetracyanoethylene to remove the visual carotenoids spectra from solutions of chlorophyll-*a* and pheophytin-*a*. Other researchers[41,47,90] have used HPLC methods to reduce the carotenoids content in chlorophyll. In order to improve on this in the absence of HPLC, diethyl ether was used in the extraction of chlorophyll (Figure 4.16). Several washings with the diethyl ether were employed before the extract was chromatographed on the silica gel stationary phase.

The chlorophyll-*a* and pheophytin-*a* obtained from this improved extraction process was much higher in quantity (Tables 4.10(b) &

4.11(b) and quality (Figures 4.10 & 4.11) compared to the previous methods. In addition, the absorption spectrum was very similar to those in the literature.[3,12,19,140]

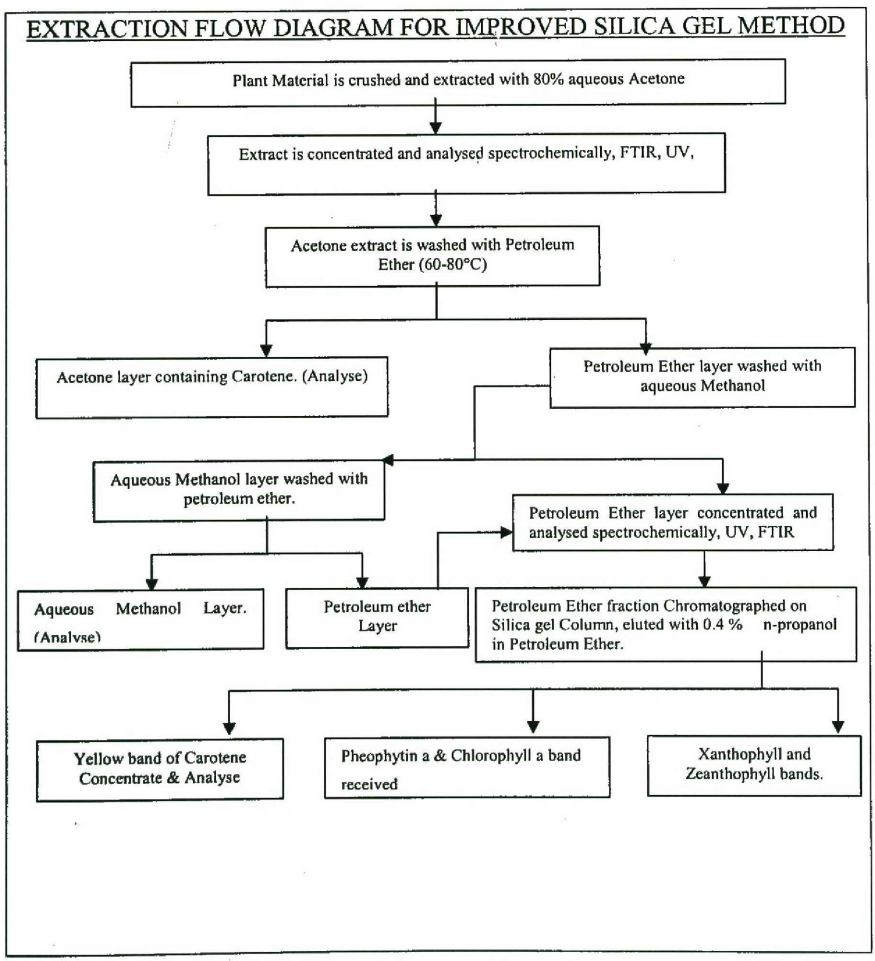


Figure 5.3 Extraction of chlorophyll using improved silica gel method 3

5.1.4 WINTER EXTRACTION METHOD (METHOD 4)

In the course of this work, it was noticed that spinach leaves extracted for chlorophyll during summer were easily extracted for chlorophyll using petroleum ether and diethyl ether and then purified by column chromatography.

In winter, however, it was observed that chlorophyll could not be extracted from spinach leaves using petroleum ether as was previously the case. Previous workers[139] have also described this difficulty in the extraction of chlorophyll. When extracted for chlorophyll with petroleum ether, the petroleum ether layer (Figure 4.14) was visibly yellowish showing that it was now richer in carotene and the carotenoids than in chlorophyll.

To overcome this apparent difficulty, after the spinach was extracted with 80% acetone and washed with petroleum ether several times, the acetone layer was then washed with diethyl ether (Figure 3.4). The petroleum ether fraction at this point removed most of the carotenoid content in the extract. When the extract in acetone was washed with diethyl ether, (Figure 4.15) the diethyl ether fraction was found to be greenish showing richness in chlorophyll pigment.

At this stage the concentration of total chlorophyll in the petroleum ether fraction was found to be 1.596 mg/L [Table 4.14(b)] while the

concentration of total chlorophyll in the diethyl ether fraction was found to be 19.618 mg/L [Table 4.15(b)].

Table 5.1 Comparison of the concentrations of total chlorophyll obtained from the different methods of extraction.

Method	Chromatographic Column	Solvent system	Concentration of total chlorophyll
Method 1	Alumina method	Butanol, ethanol & water	2.013 mg/L
Method 2	Silica method	Petroleum ether	14.529 mg/L
Method 3	Improved Silica method	Petroleum ether	27.005 mg/L
Method 4	Winter/Silica method	Diethyl ether	25.751 mg/L

From the comparison shown in Table 5.1, it can be observed that the concentration of total chlorophyll increased with improvement in the method of extraction employed in the extraction and purification of chlorophyll.

The improved silica gel method of extraction could be seen as an efficient and convenient method to obtain chlorophyll-*a*. This method is also cost-effective and reliable especially where advanced analytical chemistry laboratory automations are lacking. Thus, this method of extraction is highly recommended for isolation of chlorophyll and pheophytin from plant material.

5.2 CHARACTERIZATION

5.2.1 ULTRAVIOLET-VISIBLE SPECTROSCOPY

The absorption spectrum of chlorophyll-*a* shows a strong absorption band in the red region of the spectrum and a more intense absorption band in the blue region of the spectrum.

In some of the spectra, Figure 4.16, a prominent shoulder appears on the high-energy side of the blue band. The ultraviolet and visible spectra of chlorophyll-*a* show four distinct absorption bands labelled B_y, B_x, Q_x and Q_y bands in order of decreasing transition energies. The absorption spectra of pheophytin-*a*, on the other hand show six absorption bands.

These bands are observed at 430 nm (B_y) and 451 nm (B_x) in petroleum ether Figure 4.10 and at 429 nm (B_y) and 530 nm (B_x) in diethyl ether (Figure 4.16). The Q_x and Q_y bands are observed at 616 nm (Q_x) and 663 nm (Q_y) in petroleum ether (Figure 4.10), whereas in diethyl ether, these bands are observed at 618 nm (Q_x) and 661 nm (Q_y) (Figure 4.16).
These absorption bands are in complete agreement with data obtained by other researchers. [19,140]

The spectra can be understood on the basis of the four orbital model for porphyrins and their derivatives.

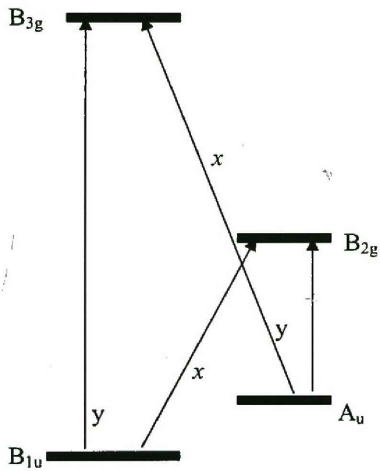


Figure 5.4 Frontier orbitals of chlorophyll

For D_{4h} metalloporphyrins, the two degenerate lowest unoccupied molecular orbitals (LUMO, e_g^*) and two nearly degenerate highest occupied molecular orbitals (HOMO, a_{1u} and a_{2u}) give rise to a strong soret band in the near-UV region and weak Q bands in the visible region. However, in the D_{2h} symmetry, the degenerate e_g^* (D_{4h}) LUMOs split into x and y components (b_{3g} and b_{2g}). The b_{3g} and a_u orbitals are more destabilized relative to b_{2g} and b_{1u} because of their orbital nodal pattern.[113] This is illustrated in Figure 5.4.

These possible electronic transitions in the above Figure, account for the peaks observed in the spectra of chlorophyll shown in Figure 4.16. The aromatic nitrogen heterocycles are known to possess low-lying n-π^* states attained by the promotion of a nonbonding electron localised on nitrogen into the lowest antibonding level of the π-system. The π^*

level is assumed to remain fixed since the main red band in the visible absorption spectra of chlorophyll-*a* and pheophytin-*a*, the first π-π^* transition differs by only 5 – 8 nm (λ_{max} 663 and 667 nm (Figure 4.10) and 661 and 666 nm (Figure 4.16).

5.2.2 INFRARED SPECTROSCOPY

The modern interpretation of chlorophyll infrared spectra is based mainly on the work of Katz and his coworkers.[57,110-112]

The region of greatest significance is the carbonyl region containing the stretching frequencies of the *C_7,**(C_{17}) propionic ester, the *C_{10} **(C_{13}^2) methylcarboxylate, the *C_9,**(C_{13}^1) carbonyl and the conjugated ring systems. The various chlorophyll-numbering systems are shown in Figure 5.5

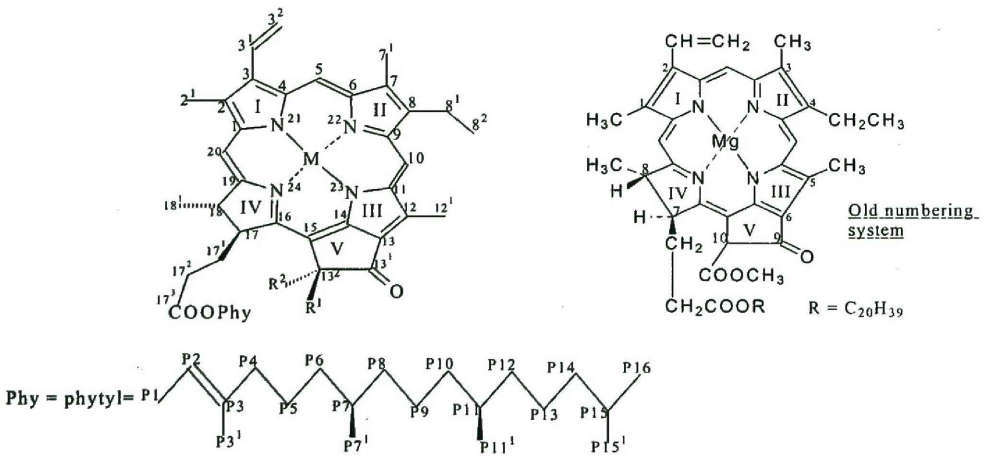


Figure 5.5 New(**) and old(*) numbering systems for Chlorophyll

The two ester groups absorb in the range 1735 – 1740 cm^{-1} in monomeric chlorophyll, the C_9 carbonyl absorbs near 1695 cm^{-1} and

in dimeric chlorophyll where the chlorophyll is bound to magnesium, it absorbs near 1650 cm^{-1}.

Infrared studies have shown that the coordination number of magnesium in chlorophyll is always larger than 4 and the coordination properties of magnesium determine the state of chlorophyll in solution. In electron donor solvents, the solvent molecules relieve the coordination unsaturation. [31,57,112,118,119]

In solvents such as pyridine, tetrahydrofuran, acetone and the like, chlorophyll is monomeric with solvent molecules in the axial positions. In non-polar solvents, the coordination unsaturation of the magnesium cannot be satisfied by the solvent, and coordination interaction of the ketone oxygen function of one chlorophyll molecule with the magnesium of another is the option that is exercised.

Thus in non-polar solvents, chlorophyll occurs as dimeric or as oligomers held together by *C=O---Mg* interactions. Figure 5.6 shows a model of C=O----Mg bond between two chlorophyll molecules. The coordination number of chlorophyll in this model is 4.

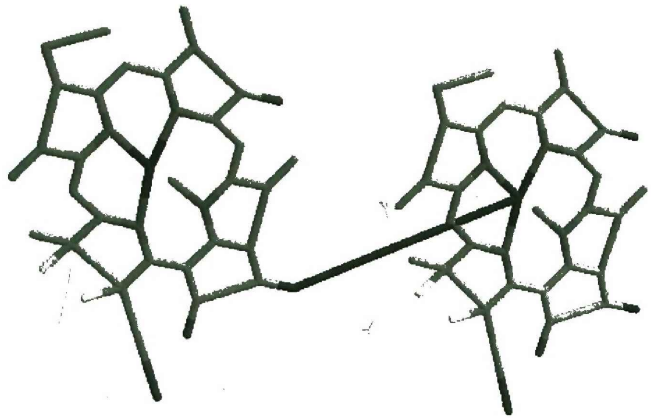


Figure 5.6 Dimeric chlorophyll held by *C=O---Mg* interaction showing magnesium with four bonds.

The presence of water in chlorophyll extraction has a special relationship.[112] The decrease of the free keto *C=O* absorption peak at 1698 cm^{-1} and the increase in the peak near 1650 cm^{-1} is due to the presence of water. Water acts as a nucleophile for chlorophyll-*a* in carbon tetrachloride (CCl_4) solution, equation [5.1].

$$Chl_2 + 2H_2O \rightleftharpoons 2Chl.H_2O \qquad [5.1]$$

Infrared analysis of chlorophyll-*a* extract in petroleum ether in the improved silica gel method, Figure 4.24 obtained from the liquid sample shows prominent absorption bands. C—H aliphatic stretching vibrations of the ligand macrocyclic ring are observed as strong bands at 2961, 2919 and 2851 cm^{-1}. The strong bands at 1455 and 1378 cm^{-1} could be regarded as alkyl C—H bending asymmetric vibrations and

bending symmetric vibrations originating from the phytal chain. And could also be due to C=C vibrations of the porphyrin ring system.
An important vibrational signal observed here is the weak signal at 3021 cm^{-1} due to N—H stretching vibration of chlorophyll converted to pheophytin. In this infrared spectra, the absorbance due to the two esters and $*C_9$ ketones (C=O), which should be observed at 1735 - 1740 cm^{-1} for monomeric chlorophyll and at 1695 – 1650 cm^{-1} are observed as weak vibrations. The fact that this very important vibration is found in this infrared spectra coupled with the presence of charge transfer transitions in the ultraviolet and visible spectra (Figure 4.11) at 615, 579 & 535nm shows that the solution obtained at this point in the analysis is chlorophyll-*a*.

The use of silica gel as the stationary phase in the purification of chlorophyll was employed. The chlorophyll-*a* obtained using this procedure were also analysed in the infrared region, Figure 4.24.
The absorption bands observed here are those of the alkyl C—H stretching vibrations at 2970, 2927 & 2876 cm^{-1}, which are in close agreement with published assignments.[31,57,112,119] There is the absence of the band at 3021cm^{-1}, which is an N—H stretching vibration arising from pheophytins.

The two ester and ketone absorption bands which appears as two peaks at 1700cm^{-1} is observed at 1719 cm^{-1} which could mean the presence of water in the chlorophyll extract.

After modification of the extraction procedure, Figure 3.3, the ultraviolet and visible spectral analysis of the chlorophyll-*a* and pheophytin-*a* obtained, show the presence of absorption bands that are consistent with literature values.[31,57,112]

The infrared spectra of this chlorophyll-*a* are shown in Figure 4.24 and 4.25. In the carbonyl stretching region, there are four notable absorption peaks at 1736, 1693, 1642 & 1557 cm^{-1}. The peak at 1736 cm^{-1} and the shoulder at 1720 cm^{-1} are ester carbonyl peaks consistent with chlorophyll absorption.[57,112]

The 1693cm^{-1} band is due to the free keto carbonyl and the peak at 1642 cm^{-1} is the peak due to aggregation of chlorophyll in solution. The broad band at 3404 cm^{-1} could be due to N—H stretching vibration and O—H stretching vibration probably originating from the acetic acid solvent.

5.2.3 MASS SPECTRAL ANALYSIS

Electrospray ionization mass spectra of chlorophyll-*a* produced several fragmentation peaks. These spectra are displayed in Figures 4.32 - 4.35.

Important fragmentation peaks for chlorophyll-*a*, observed and calculated mass to charge (m/z) ratios and their assignments are displayed in Table 5.2.

The most important peaks in this analysis are the peak with *(m/z)* 591.3_{obs} ($590.9_{calc.}$) and 613.2_{obs} ($613.9_{calc.}$) The peak at 613 has a relative abundance of 100%. This peak is due to the fragmentation of chlorophyll with the loss of the phytyl chain. The relative abundance of this peak shows the extract to be chlorophyll-*a*.

The peak *(m/z)* 591.3 results from the fragmentation of pheophytin-*a* formed in solution as a degradation product. The relative abundance of this peak at 591.3 (~10 %) shows that the percentage of chlorophyll that has converted into pheophytin is low.

In the mass spectrum of pheophytin-*a*, (Figures 4.32 and 4.33) the peak due to the loss of the phytyl chain during fragmentation is observed at a mass to charge (m/z) ratio of 593.2. This peak has a relative abundance of 100% also indicating the loss of the phytyl chain during fragmentation.

The molecular ion peak (M^{+1} or M^{+2}) of chlorophyll at *(m/z)* 894_{cal} or (895_{cal}) has a relative abundance of less than 5%.

Chlorophyll-*a* in water forms a dimer with a hydrogen bond, see [Figure 5.7(a and b)]. The peak at *m/z* $1823_{obs\ \&\ cal}$ indicates that the chlorophyll in acetic acid solution had dimerized.

Table 5.2. Fragmentation analysis for chlorophyll.

Observed *m/z*	**Assignment/Analysis**	**Calculated *m/z***
537.4		
555.3	Chla – phytyl - $COOCH_3$	893.5 – 278.6 – 59 = **555.9**
591.3	Chla – phytyl – Magnesium	893.5 – 278.6 – 24 = **590.9**
613.2/614.3	Chla – phytyl – proton	893.5 – 278.6 – 1 = **613.9**
635.2		
673.3	Chla – phytyl + $COOCH_3$	893.5 – 278.6 + 59 = **673.9**
695.1	Chla - $COOCH_3$ – $CH_2CH_2COOCH_3$ – $2H_2O$ – CH_3	893.5 - 59 – 87 – 36 – 15 = **696.5**
873.2	Chla – Magnesium + 2protons	893.5 – 24 + 2 = **871.5** (M+2)
1823	Chla. + water + chla + water (dimer)	893.5 + 18 + 893.5 +18 = **1823**
1799	Chla + chla	893.5 + 893.5 = **1797**
1039.9	1823 – 2[CH_2CH_2COO phytyl] + 2(water) – 2($COOCH_3$)	1823 – 700 + 36 – 118 = **1041**
1097.9	1823 – 2[CH_2CH_2COO phytyl] + 2(water) – $COOCH_3$	1823 – 700 + 36 – 59 = **1099**
1157.0	1823 – 2[CH_2CH_2COOphytyl] + 2(water)	1823 – 700 + 36 = **1159**
1203.2	[Chla + H_2O + chla +H_2O] – 2phytyl - $COOCH_3$	1823 – 557.2 – 59 = **1206.8**
1227.3	Chla + chla – 2phytyl	1787 – 557.2 = **1229.8**

The presence of these peaks and their fragmentation products at the above *m/z* values are indicative of the fact that the substance extracted is chlorophyll.

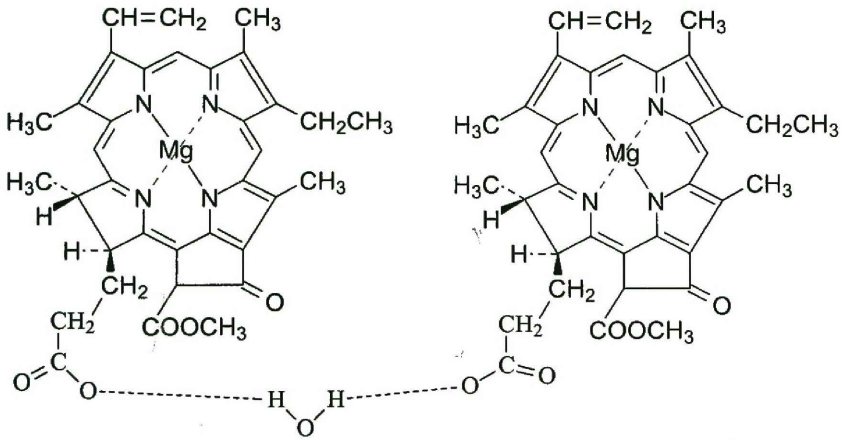


Figure 5.7(a) Chlorophyll-*a* and water dimer

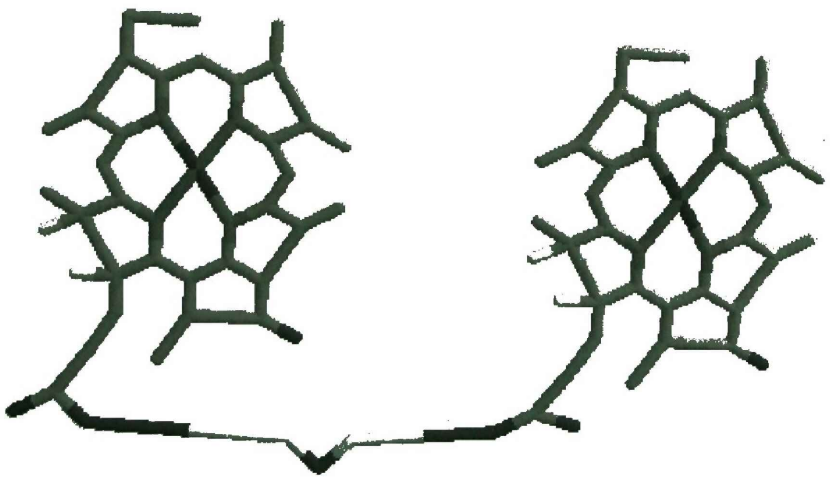


Figure 5.7(b) Chlorophyll-*a* –water dimer molecule model

The fragmentation of chlorophyll-*a* is as follows:

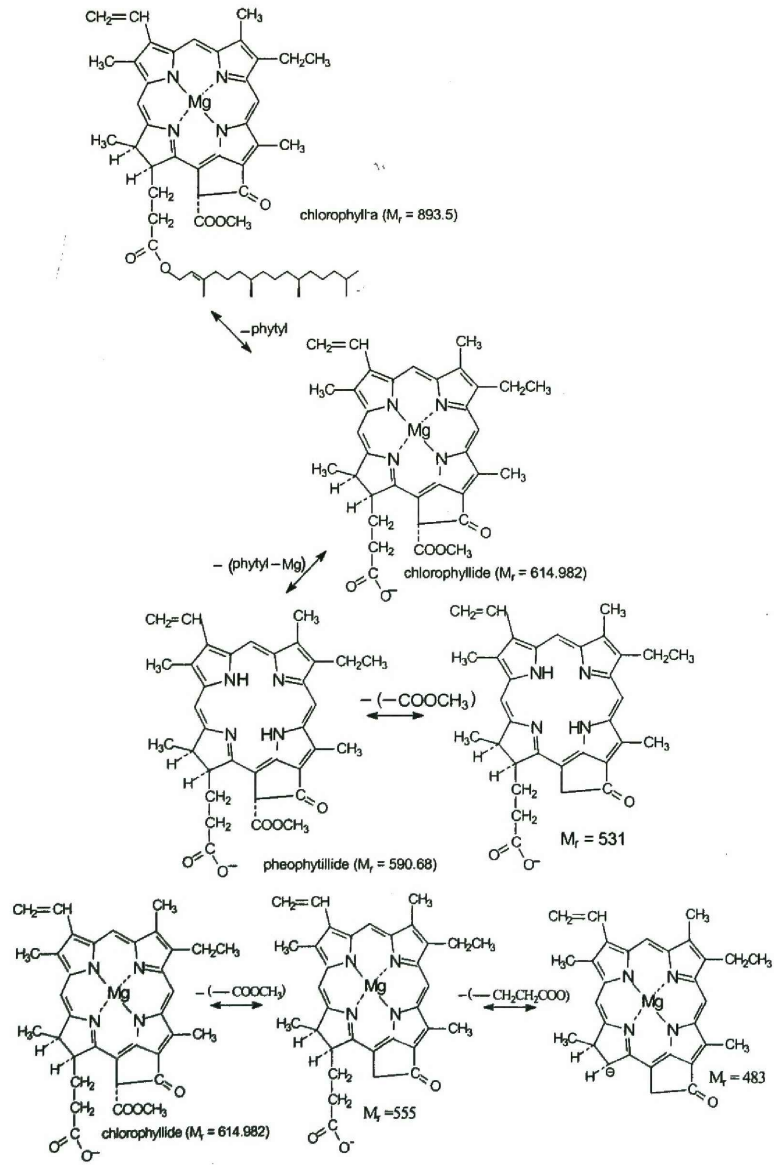


Figure 5.8 Fragmentation scheme for chlorophyll-*a*

The fragmentation pattern for the pheophytin could also be described similarly to that of chlorophyll-*a*.

The pheophytin molecular ion peak at *m/z* 871.5_{cal} is observed, but the pyrrolic ion without the phytyl moiety is a strong signal (nearly 100%) observed at *m/z* 593.2_{obs} (Figure 4.32). Other signals of interest (Figure 4.33) are those of dimeric pheophytin-*a* at *m/z* 1777.3_{obs} and the peaks due to the fragmentation of dimeric pheophytin-*a* at *m/z* 1064, 1185, 1321, & 1362. The fragmentation pattern of pheophytin-*a* is summarized in Table 5.3 and illustrated in Figure 5.9.

Table 5.3. Fragmentation analysis for pheophytin-*a*.

Observed *m/z*	**Assignments/Analysis**	**Calculated *m/z***
593.2	Pheo - phytyl	871.5 – 278.6 = **592.9**
533.3	Pheo – phytyl – $COOCH_3$	871.5 – 278.6 – 59 = **534**
1777.3	Pheo.H_2O.pheo.H_2O	871.5 + 18 + 871.5 + 18 = **1779**
1185.0	Pheo.H_2O.pheo.H_2O – 2phytyl – $2H_2O$	1779 – 557.2 – 36 = **1185.8**
1124.0	Pheo.H_2O.pheo.H_2O – 2phytyl – $2H_2O$ – $COOCH_3$	1185.8 – 59 = **1126.8**
1064.1	Pheo.H_2O.pheo.H_2O – 2phytyl – $2H_2O$ – $2COOCH_3$	1185.8 – 118 = **1167.8**
1601.9	Pheo.H_2O.pheo.H_2O – $2CH_2CH_2COOCH_3$	1779 – 2 x 87 = **1605**
1569.2	Pheo.H_2O.pheo.H_2O – $2CH_2CH_2COOCH_3$ – $2H_2O$	1779 – 174 – 36 = **1569**
1291.0	1569 - phytyl	1569 – 278.6 = **1290.4**
1321.1	1291 + methanol	1291.0 + 32 = **1323**
1362.0	Pheo.H_2O.pheo.H_2O – $2CH_2CH_2COOCH_3$ - $2H_2O$ – $COOCH_3$	1779 – 322 – 59 – 36 = **1362**

The fragmentation scheme for pheophytin-*a* is given below:

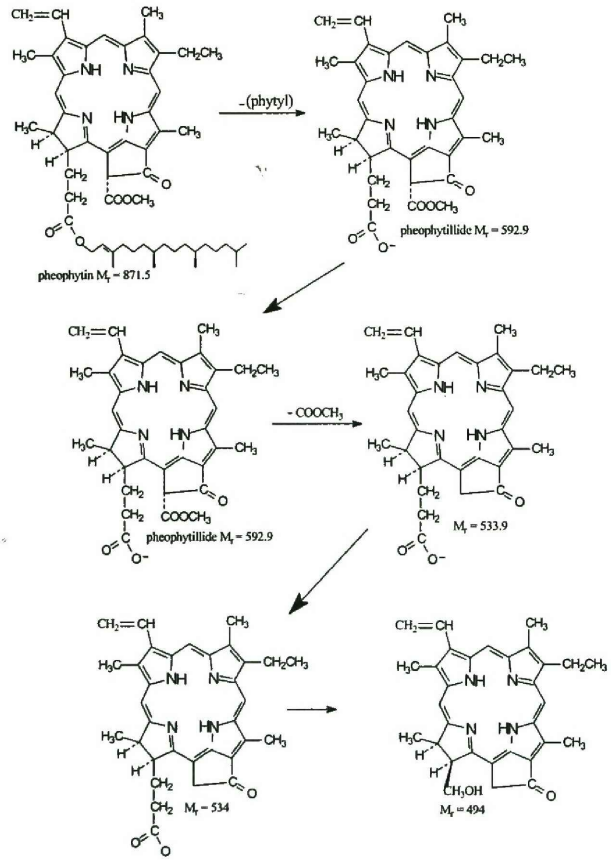


Figure 5.9 Fragmentation scheme for pheophytin-*a*.

5.3 METAL INSERTION

The metals cobalt, zinc, copper, nickel, and chromium were inserted in the centre of the chlorophyll-*a* tetrapyrrole ring.

5.3.1 ULTRAVIOLET-VISIBLE SPECTRA OF METALLO-CHLOROPHYLLS

Complexation of pheophytin-*a* to obtain the desired metal complex in this research was successful as shown by the absorption spectra of chlorophyll-*a* (Figure 4.16), pheophytin-*a* (Figure 4.17) and metal pheophytin complexes (Figure 4.18 – 4.23)

The absorption spectrum of chlorophyll-*a*, shows two prominent absorption bands characteristic of chlorophyll-*a*, one at 429 and the other at 662 nm (Figure 4.16), which are shifted upon demetallation. The absorption band at 429 nm shifts to 409 nm while the absorption band at 661 nm shifts to 666 nm in pheophytin-*a*. The absence of magnesium in the centre of the tetrapyrrole ring of chlorophyll also results in the appearance of a new band at 505 nm (Figure 4.17).

When pheophytin-*a* is complexed (Figure 4.18 – 4.23), the absorption bands at 409 nm and 666 nm are again shifted, for example, in cobalt(II) pheophytin-*a*, Figures 4.18-431 nm and 655 nm, respectively. The new absorption band at 505 nm, Figure 4.17, which is observed when chlorophyll-*a* is demetalled is not found in metalled pheophytins, Figures 4.18 – 4.23 confirming successful metal insertion.

The metallation reaction is expected to follow the following process in Figure 5.10. In this reaction process, chlorophyll-*a* is converted to pheophytin-*a* in acidic medium and pheophytin-*a* combines with the appropriate metal ion [M^{2+}/M^{3+}] to form a metallochlorophyll

$$\text{Chl-}a + 2H^{+} \longrightarrow \text{Phe-}a + Mg^{2+}$$

$$\text{Phe-}a + M^{2+} \longrightarrow \text{Mphe} + 2H^{+}$$

Figure 5.10 Metallation of chlorophyll equation

Acetic acid has been used in this metallation process because acetic acids acts to protonate the conjugated keto groups at position C-13[1] and or C-3[1] increasing the s-character and acidity of the N-atoms of ring I or III or both.

Reducing the acidity of the amino nitrogens is expected to lower the rate and yield of metal insertion.[10,59]

The absorption spectrum of the solution obtained with cobalt(II) acetate (Figure 4.18) shows two absorption bands at 431 and 655 nm. The change in this absorption spectrum, Figure 4.18, is confirmation of successful metallation of the pheophytin. The metal pheophytins obtained, are hereby referred to as metal pheophytin complexes.

Other metal acetates were also employed to obtain metal pheophytins of these metals. Metal pheophytins obtained are cobalt, zinc, copper, chromium, nickel and trisodium copper chlorophillin (Merck) (Figures 4.18 - 4.24). The general structural formula of the metal pheophytin complexes is shown in Figure 5.11.

Spectral variation influenced by the central metal atom results from the demetallation of chlorophyll-*a* to pheophytin-*a* and metallation of pheophytin-*a* to metal pheophytin-complex.

The absorption bands in chlorophyll-*a* and pheophytin-*a* labelled B_y, B_x, Q_x and Q_y show pair wise dependences. When the central metal atom is changed from magnesium in chlorophyll to other metals, the B_x and Q_y transitions are only slightly affected by changing the central metal in the tetrapyrrole ring. On the other hand, strong and distinct shifts are observed in the B_y and Q_x bands. Shifts in these absorption bands with respect to chlorophyll-*a* and pheophytin-*a* are displayed in Table 5.4.

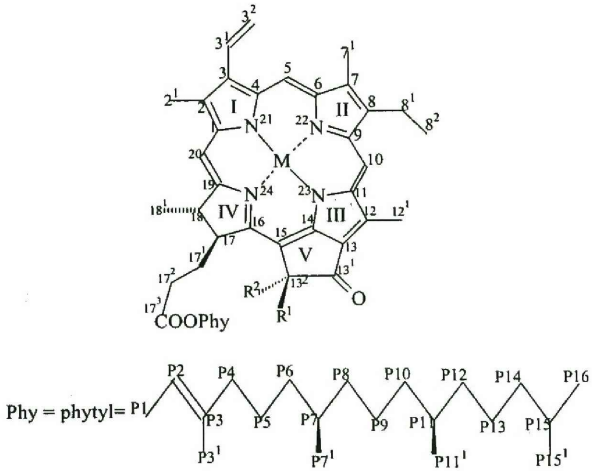


Figure 5.11 Metallated Chlorophylls

Complex	B_y	B_x	Q_x	Q_y	Figure
Mg^{2+}	429	530	617	661	4.16
$2H^{+}$	409	505	607	666	4.17
Co^{2+}	431	—	—	655	4.18
Cr^{3+}	422	—	—	594	4.20
Cu^{2+}	411	—	—	648	4.21
Zn^{2+}	428	—	—	659	4.23
Ni^{2+}	423	—	—	652	4.24

Table 5.4 Visible absorption spectral properties of prepared metallochlorophylls in acetic acid.

The large shifts of the Q_x and B_y bands can be rationalised qualitatively by the four orbital model. According to this model, the ultraviolet and visible spectra result from transitions among four orbitals. These are the two highest occupied molecular orbitals

(HOMO) and the two lowest unoccupied molecular orbitals (LUMO). These four orbitals are a_{2u} (HOMO-1), a_{1u} (HOMO), e_{gx} (LUMO) and e_{gy} (LUMO+1).

From this assignment, the B_y is a transition from a_{2u} to e_{gy}, the B_x is a transition from a_{1u} to e_{gy}, the Q_x is a transition from a_{2u} to e_{gx} and Q_y is a transition from a_{2u} to a_{1u}. The a_{2u}orbital have high electron densities around the four nitrogens nearest to the metal in the centre of the tetrapyrrole ring of the ligand, whereas the e_{gx} and e_{gy} orbitals have substantial electron densities on only two nitrogens and the a_{1u} orbital has almost no electron density at the nitrogens.

The metallation of a tetrapyrrole molecule in solution is believed to consist of the following steps: (a) deformation of the tetrapyrrole ring, (b) outer-sphere association of the solvated metal ion and tetrapyrrole, (c) exchange of a solvent molecule with the first pyrrolenine nitrogen atom, (d) chelate-ring closure with the expulsion of more solvent molecules, (e) first deprotonation of a pyrrole nitrogen and (f) second deprotonation of the other nitrogen, which will lead to the formation of the metallochlorophyll.[109]

The protons on two of the pyrrole nitrogen atoms prohibit the metal ion to reside in the centre of the porphyrin plane; rather, the metal ion will lie above the ring plane and form bonds to a number of solvent molecules. [45]

5.3.2 INFRARED SPECTRA OF METALLOCHLOROPHYLLS

Infrared spectra of chlorophyll-*a*, pheophytin-*a* and metallochlorophylls prepared are displayed in Figures 4.24 - 4.31. Prominent absorption bands of metallochlorophylls are displayed in Figure 5.12 to 5.17.

The frequencies of these prominent absorption bands of the metallochlorophylls are collected in Table 5.5. The infrared spectra obtained compare favourably with published data[31,112] for the structure of metallochlorophylls shown in Figure 5.11.

The infrared spectra of the metallochlorophylls have several prominent absorption bands among these bands is the ester carbonyl absorption band which is found at about 1735cm^{-1}.

The free keto carbonyl absorption band is around 1695cm^{-1} and the coordinated keto carbonyl absorption band C=O---Mg is observed at 1625 cm^{-1}. The skeletal C=C & C=N absorption is at ~1608 cm^{-1} and the aggregation peak at 1652 cm^{-1}. The skeletal C=C absorption band in metallochlorophylls show stretching vibrations that are metal sensitive, that shift upon metal insertion into the ligand. [57,112,118]

The bands at 1739-1710 cm^{-1} in these metallochlorophylls have been assigned as ester carbonyl absorptions. The bands at about 1642 – 1625 cm^{-1} are aggregation peaks. These peaks are absent in some metallochlorophylls. The most important metal sensitive absorption band is that described as IR4 by Masuo Fujiwara and Mitsuo

Tasumi[119] found at 1555-1549 cm^{-1} depending on the metal and which arises from C=C stretching vibrations. These absorption bands are also found at the wavenumbers 1576-1565 cm^{-1} depending on the metal.

The peaks at 1584 – 1506 cm^{-1} are also metal sensitive resulting from the macrocyclic ring of the tetrapyrrole. In chlorophyll and pheophytin, this band is observed at 1506 and 1523 cm^{-1} respectively. This absorption band is at a higher frequency for the metallochlorophylls (1584 – 1548 cm^{-1}), this may be interpreted to indicate a greater stability for the metallochlorophylls than for chlorophyll.

Most of the pheophytin absorption positions are independent of the metal ion, while the C—C and C—N stretching absorption of the pheophytin macrocycle are sensitive to the particular metal ion present in the tetrapyrrole ring. The bands at ~1029cm^{-1} and ~740cm^{-1} in chlorophyll and pheophytin are due to C—O ester and π(C—H) stretching vibrations which do not change upon metal insertion.

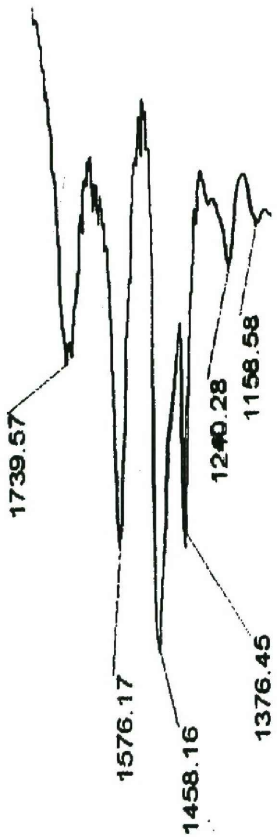


Figure 5.12 Cobalt(II) pheophytin-*a*

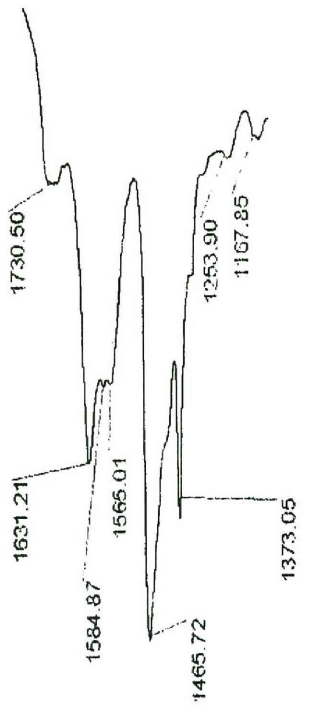


Figure 5.13 Copper(II) pheophytin-*a*

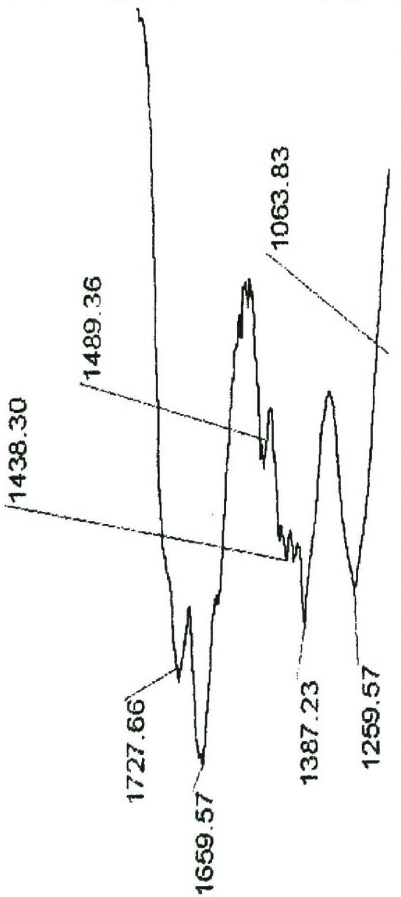


Figure 5.14 Chromium(III) pheophytin-*a*

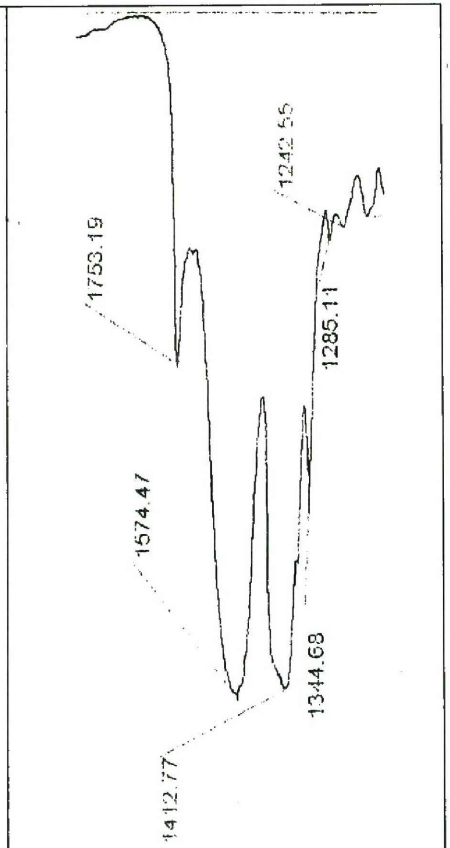


Figure 5.15 Nickel(II) pheophytin-*a*

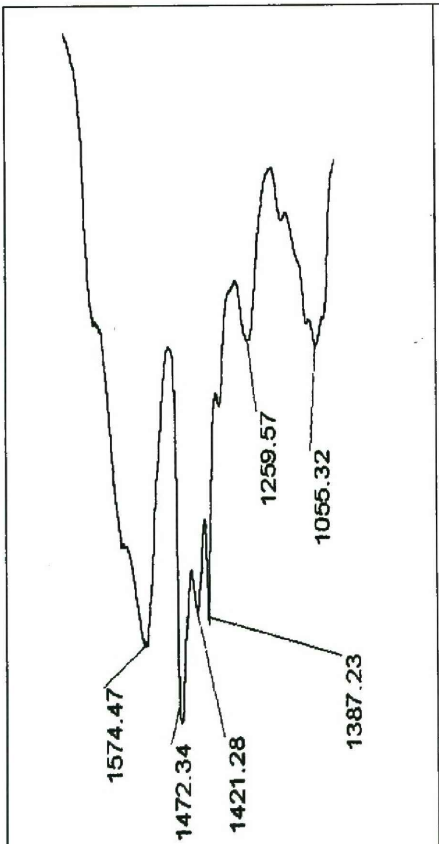


Figure 5.16 Zinc pheophytin-*a*

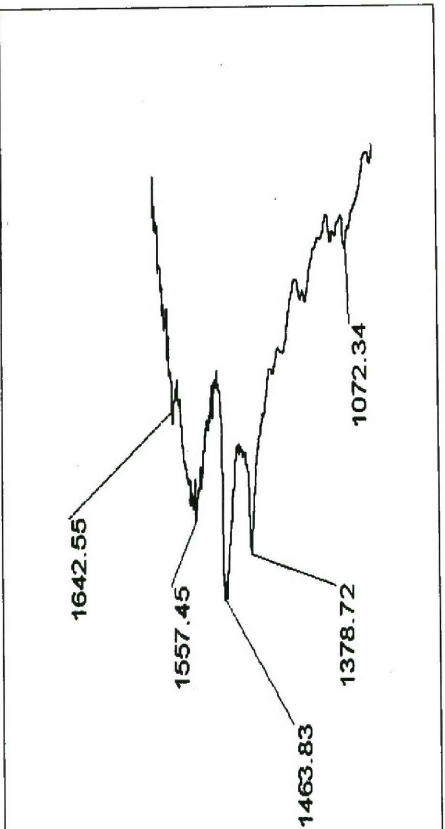


Figure 5.17 Trisodium copper pheophytin-*a*

Infrared absorption bands of synthesized metallochlorophylls and their assignments.

Complex	**Band**	**Signal strength**	**Assignment**
Cobalt(II) pheophytin-*a* (Cophe) (Figures 4.27 and 5.12)	1736	m	υ(C=O)
	1719	sh	υ(C=C)
	1576	sh	
	1458	sh	υ(C-O) ester (stretch) and υ(O-H)
	1376	m	bending
	1240	w	
	1158	w	υ(C-H)
	1058	vw	υ(C=C)
	1022	w	
	895	w	υ(C-C)
	731	m	υ(C-H)
Copper pheophytin-*a* (Cuphe) (Figures 4.28 and 5.13)	1730	w	υ(C=O)
	1631	m	υ(C=C) or (C=O---Metal)
	1584	w	υ(C-O) ester
	1565	w	
	1465	s	
	1373	sh	υ(C-H)
	1253	w	
	1167	w	
	1055	w	υ(C-C)
	1028	w	
	730	m	υ(C-H)
	691	m	
Zinc pheophytin-*a* (Znphe) (Figures 4.31 and 5.16)	1574	s	
	1472	s	υ(C=C)
	1421	w	υ(C-O) ester (stretch) and υ(O-H)
	1387	sh	bending
	1259	w	υ(C-H)
	1055	s	
	936	vw	υ(C-C)
	731	vw	υ(C-H)

Nickel pheophytin-*a* (Niphe) (Figures 4.30 and 5.15)	1753	sh	υ(C=O)
	1574	s	
	1412	s	υ(C-O) ester (stretch) and υ(O-H) bending
	1344	w	
	1285	vw	
	1242	vw	υ(C-H)
	1165	w	υ(C=C)
	1114	vw	
	1063	vw	υ(C-C)
	740	vw	
	680	s	υ(C-H)
	621	vw	
Chromium pheophytin-*a* (Crphe) (Figures 4.29 and 5.14)	1727	s	υ(C=O)
	1659	s	υ(C=C) or (C=O---Metal)
	1489	w	υ(C-O) ester (stretch) and υ(O-H) bending
	1438	vw	
	1387	w	
	1259	s	υ(C-H)
	1106	sh	υ(C=C)
	1063	w	
	1012	w	υ(C-C)
	893	w	
	672	w	υ(C-H)

Table 5.5 Infrared absorption bands of cobalt(II) pheophytin-*a* (Cophe) in nujol

5.3.3 ELEMENTAL ANALYSIS

The insertion of cobalt and other metal ions in place of magnesium in the centre of the chlorophyll macrocycle was successful as shown by elemental analyses result obtained (Figures 4.38 – 4.42 and Table 4.25).

The percentage composition by mass of Carbon, hydrogen and nitrogen calculated and found are in close agreement with each other.

5.3.4 MASS SPECTRA OF COBALT(II) PHEOPHYTIN-*a*:

The insertion of cobalt(II) in the centre of the tetrapyrrole ring of chlorophyll in place of magnesium was successful. This is evident in the electrospray ionization mass spectrum (ESI-MS) of this complex (Figure 4.36).

The cobalt(II) pheophytin-*a* molecular ion peak at 928.13_{calc} is not a strong signal; this is because the chlorophylls provide only pyrrolitic fragments in mass spectral analysis.[126]

The most important signal is at *m/z* 648.66_{obs} due to the cobalt(II) pheophytin-*a* complex without the phytyl chain. The observed *m/z* of this signal at 648.66 and the calculated *m/z* of this signal at 648.53 is also an indication that cobalt was inserted.
This signal (*m/z* 648.66) is found in the spectrum of chlorophyll-*a* and pheophytin-*a* at *m/z* 613.2 and *m/z* 593.2 respectively. Whereas the relative abundance of this signal is about 100% in the spectrum of chlorophyll-*a* and pheophytin-*a*, in cobalt(II) pheophytin-*a*, the signal has an abundance of about 85%.

The other signals of interest in the cobalt(II) pheophytin-*a* mass spectrum are those observed at *m/z* 825.49 and 1002.32. These peaks result from the fragmentation and loss of the C(15)-CO_2Me group and rearrangement of these groups in the chlorophyll macrocycle.

The fragmentation analysis for cobalt(II) pheophytin-*a* is shown in Figure 5.18 and Table 5.6 respectively.

The fragmentation of cobalt(II) pheophytin-*a* is illustrated below:

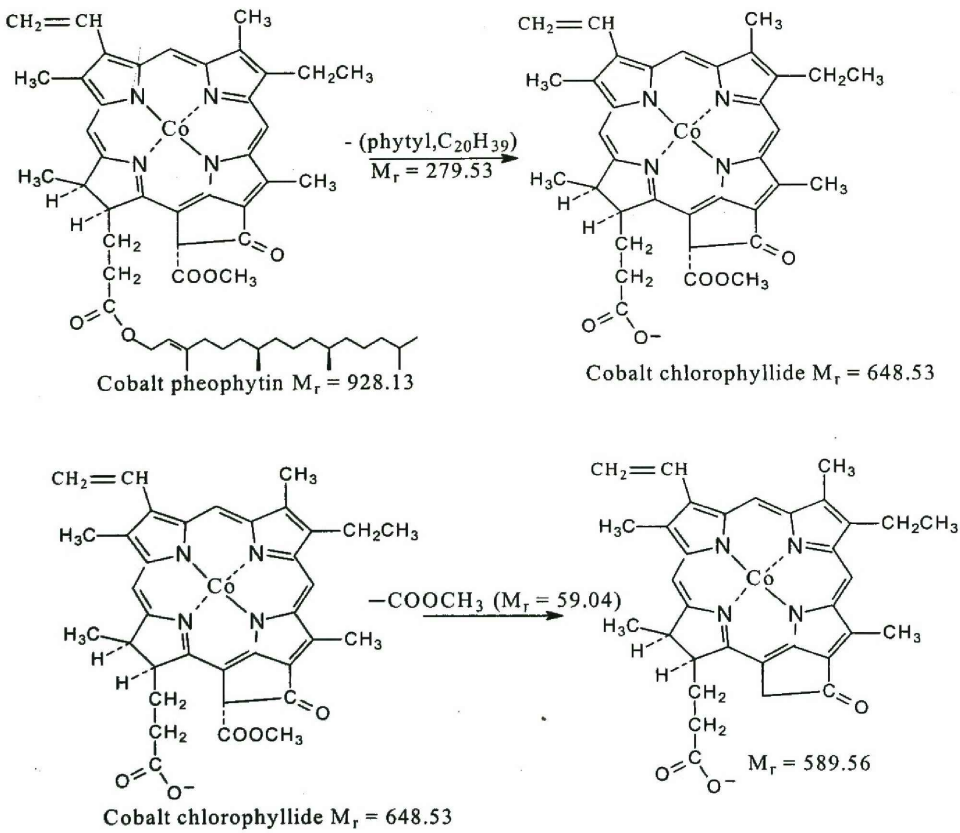


Figure 5.18 Fragmentation scheme for cobalt(II) pheophytin-*a*.

Table 5.6 Fragmentation analysis for cobalt(II) pheophytin-*a*.

Observed *m/z*	Assignments/Analysis	Calculated *m/z*
294.95	Phytyl + methyl	279.53 + 15.03 = **294.56**
312.63	Phytyl + methanol	279.53 + 32.04 = **311.57**
648.66	Cophe – phytyl	928.13 – 279.53 = **648.53**
825.49	Cophe – $CH_2CH_2COOCH_3$ – methyl	928.13 – 87.10 – 15.03 = **826.0**
1002.32	Cophe + $COOCH_3$ + methyl	928.13 + 59.04 + 15.03 = **1002.2**
1893	Cophe + water + Cophe + water	1893
1179.18	Cophe + methyl + $2(CH_3COOCo^+)$	928.13 + 15.03 + 235.96 = **1179.12**
1356.2	Cophe + Cophe – 2phytyl + $COOCH_3$	1856.26 – 559.06 + 59.04 = **1356.24**

5.4 KINETICS OF OXIDATION OF COBALT(II) PHEOPHYTIN-*a* (Cophe) BY HEXAAQUACHROMIUM(III) CATION ($[Cr(H_2O)_6]^{3+}$)

The reaction of cobalt(II) pheophytin-*a* with hexaaquachromium(III) cation is a complementary reaction in which the cobalt(II) is oxidized to cobalt(III) and the chromium(III) is reduced to chromium(II), as shown in equation [5.2].

$$Co^{II}phe + [Cr(H_2O)_6]^{3+} \rightarrow Co^{III}phe + [Cr(H_2O)_6]^{2+} \qquad [5.2]$$

The oxidation reaction of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation followed a pseudo first order kinetics. The oxidation reaction was slow, an indication that the cobalt(II) ion is not easily oxidized to cobalt(III).

The kinetic stability of the cobalt ion in the centre of the chlorophyll macrocycle is comparable to results obtained by other workers [36,147-149] in this field, which show that transition metals coordinated to the chlorophyll macrocycle provide an increase in the stability[131] of the chlorophyll macrocycle. This stability is reflected in the activation energy of the electron transfer reaction.

In the study of the rate of pheophytinization of zinc bacteriochlorophyll-*a* and magnesium bacteriochlorophyll-*a* by Kobayashi and coworkers,[58] the rate of pheophytinization was found to be pseudo-first order. Zinc bacteriochlorophyll-*a* required a stronger acid for pheophytinization than magnesium bacteriochlorophyll-*a*.

The high resistance of zinc bacteriochlorophyll-*a* to acid pheophytinization was explained by invoking the inductive effects of the central metal by comparing the Mg—N bond with the Zn—N bond. Higher ionicity was expected for the Mg—N bond because the electronegativity (E_N) of magnesium (E_N = 1.2) is lower than that of zinc (E_N = 1.6).

The cobalt(II) pheophytin-*a* complex in this study is stable and less prone to degradation. The pseudo first order reaction observed could also be explained by invoking the inductive effect of the central metal by comparing the Mg—N bond and the Co—N bond. Higher ionicity is also expected for the Mg—N bond because the electronegativity

(E_N) of magnesium (E_N = 1.2) is also lower than that of cobalt (E_N = 1.7).

The higher electron density in the chlorophyll-*a* macrocycle and on the nitrogen atoms is expected to assist in electrophillic attack of proton on nitrogen resulting in lability of the magnesium when acidified. As a result, magnesium is easily exchanged by acidification to form the derivative or degradation product pheophytin in solution. This is also followed by a colour change from green to olive green.

The hexaaquachromium(III) cation[142-146] is acidic according to equation [5.3]

$$[Cr(H_2O)_6]^{3+} \rightleftharpoons H^+ + [Cr(H_2O)_5OH]^{2+} \qquad [5.3]$$

Since this could occur by the loss of a proton from coordinated water, the complementary oxidation reaction between cobalt and chromium may take place by electron transfer in this manner.

5.5 MECHANISM OF OXIDATION

The proposed mechanism of the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation in solution is an outer-sphere reaction mechanism. [138]

This is because the pheophytin-*a* ligand to which the cobalt(II) is coordinated does not have a bridging group which is common to the coordination sphere of both cobalt(II) pheophytin-*a* and the hexaaquachromium(III) cation. Both reactants also have to rearrange

before electron transfer could be take place. The chlorophyll macrocycle being relatively large takes time for this rearrangement to occur.

This could explain the relatively slower rate of this reaction compared to the normal rates experienced in outer-sphere mechanisms.[138] As a result, the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) cation in hydrochloric acid medium is a complementary outer-sphere electron transfer reaction in which, the cobalt is oxidized ($Co^{2+} \rightarrow Co^{3+}$) and the chromium is reduced ($Cr^{3+} \rightarrow Cr^{2+}$). This reaction could therefore be represented as shown in equation [5.2],

5.6 ROLE OF MAGNESIUM IN CHLOROPHYLL

The magnesium atom in chlorophyll plays an important electronic role in the excited states of chlorophyll. A look at the spectroscopic spectra of chlorophyll-*a*, pheophytin-*a* and cobalt(II) pheophytin-*a* complex shows the difference in the absorption spectra of chlorophyll-*a* and its magnesium free derivative pheophytin-*a* (Figures 4.16 and 4.17). When the spectra of chlorophyll-*a* and pheophytin-*a* are compared to the absorption spectra of the cobalt(II) pheophytin-*a* complex, it is evident that some electronic transitions in chlorophyll-*a* have been affected as a result of the removal of magnesium from the tetrapyrrole ring of chlorophyll. New absorption bands resulting from the demetallation observed at 505 – 507 nm in the pheophytin are not observed in the cobalt(II) pheophytin-*a* complex.

There is also a change in colour from green (in chlorophyll) to olive green (in pheophytin). The infrared spectra of chlorophyll-*a* and complexed pheophytin show shifts in absorption bands (Figures 5.12 to 5.17 and Table 5.5). This may have occurred due to expansion of the tetrapyrrole macrocycle once a different transition metal is inserted or co-ordinated in the tetrapyrrole macrocycle. Magnesium forms a five co-ordinate structure due to the lack of *d*-orbitals while transition metals could form six co-ordinates due to the presence of *d*-orbitals.

The most important use of chlorophyll in nature is in photosynthesis. Chlorophyll functions in the channelling of sunlight energy into chemical energy through the process of photosynthesis. The energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and oxygen as shown in equation [1.1]. [3,9,12,59]

In this photosynthetic reaction, electrons are transferred from water to carbon dioxide. The carbon dioxide is reduced by water in the process while the water is oxidized forming oxygen resulting in the transfer of four electrons in the process, equation [5.4].

$$4OH^- \rightarrow 2H_2O + O_2 + 4e^- \qquad [5.4]$$

Chlorophyll assists in this transfer when chlorophyll absorbs light energy, an electron in chlorophyll is excited from a lower energy state to a higher energy state. In this higher energy state, this electron is

readily transferred to another molecule. This starts a chain of electron transfer steps which ends with an electron being transferred to carbon dioxide.[1] Thus, chlorophyll is at the centre of the photosynthetic oxidation-reduction reaction between carbon dioxide and water.

The absence of magnesium in chlorophyll stops this vital photosynthesis reaction. How the magnesium supports this process is yet to be fully determined.

CHAPTER SIX

CONCLUSIONS

6.1 CONCLUSION

A simple, rapid and efficient method for extracting chlorophyll-*a* and pheophytin-*a* from spinach leaves has been developed

The purity of chlorophyll-*a* and pheophytin-*a* has been determined by ultraviolet-visible, infrared and mass spectroscopic methods and found to be in agreement with results obtained by previous workers[19,59,140] in this field.

The problem of extracting chlorophyll-*a* with aqueous acetone in winter[139] has also been solved. This has been achieved by modifying the extraction of chlorophyll using petroleum ether and diethyl ether instead of petroleum ether only.

As reported in the literature, acidification of chlorophyll-*a* has led to the removal of magnesium, enabling complexation of pheophytin by several metal ions. The metals cobalt(II), copper(II), chromium(III), nickel(II) and zinc(II) have been inserted into the chlorophyll macrocycle to give the corresponding metal pheophytin complexes. These have been fully characterised by spectrophotometric methods and by elemental analysis, thus opening up an area of study of natural metal pheophytin complexes that has been hampered by uncertainty in purity and difficulties in extraction.

In order to check on the mechanism of electron transfer in these systems, the oxidation of cobalt(II) pheophytin-*a* by hexaaquachromium(III) has been investigated. This is the first time that a study of this nature has been done, thus opening up a new area of reaction mechanism involving metal pheophytin complexes and macrocyclic ligands like porphyrin, porphrazines and phthalocyanines.

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