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Optical and Structural Modifications of γ irradiated Cr-39 Polymers

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Abstract The UV-Visible absorption spectra of CR-39 polymer, unirradiated and irradiated to gamma radiation up to 500 kGy dose were studied. The development of new peaks, shifting of absorption bands and their broadening as a result of gamma irradiation were observed and analyzed. The values of optical constant like direct and indirect band gaps have been determined. The values of indirect band gap have been found to have lower values then the corresponding values of direct band gap. The increase in carbon conjugation length and size of carbon clusters has also been pointed out from the results of UV-Visible spectroscopy.

1. INTRODUCTION

CR-39 is a polymer formed from diallyl monomer made by polymerization of diethyleneglycol bis allylcarbonate (ADC) in presence of diisopropyl peroxydicarbonate (IPP) initiater. The presence of the allyl groups allows the polymer to form cross- links; therefore, it is a thermoset resin. CR-39 is transparent in the visible spectrum and is almost completely opaque in the UV range. It has high abrasion /scratch resistance and has weight about half of the glass. It is an advantageous material for making eyeglasses and sunglasses. CR-39 is also resistant to most solvents and other chemicals, and to material fatigue. It is also used in a number of industrial and medical applications. The most recent studies with CR-39 involve neutron gamma and high energy ion irradiation induced changes in its structure and properties.

The ion irradiation of polymers with X-rays/ γ-rays or swift heavy ions deposit high amount of energy in the polymers along the track of their passage creating the formation of free radicals, ion tracks, cross linking, evolution of

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volatile species (1–3). Chong et al. (4) has been made a study on the UV-VIS and FTIR spectra of CR-39 plastics irradiated with 50 kVp tube X-rays in the dose range 0 and 45 MR. The optical transmittance over the wavelength region of 200–1000 nm was found to decrease with the X-ray exposure, much greater decrease being observed in the UV region. The IR absorption spectra of the irradiated samples show the presence of two new strong absorption bands at the frequencies 655 and 2340 cm^{-1} i.e. an indicative of the gas CO_2 produced inside the plastic. The absorbance of these bands increases linearly with the X-ray dose. Fink et al. made an attempt of FTIR studies on low energy Ar ion irradiated Polycarbonate [5] using nuclear magnetic resonance spectroscopy. Malek et al. studied the X-ray and γ- ray induced degradation of Cr-39. They studied the diffusion of CO_2 with time. Navarro et al (7) showed that PC irradiation is accompanied with the preferential release of carbon monoxide followed by minor production of hydrogen, carbon dioxide and methane.

The effects of 320 keV Ar and 130 keV He ions at fluences ranging from 1×10^{13} to 2×10^{16} ions/cm^2 ion-beam bombardment on the physical and chemical properties of poly CR-39 have been investigated by Abdul-Kader et al. (8). UV–VIS spectra of bombarded samples reveal that the optical band gap decreases with increasing ion fluence for both Ar and He ions. In the FTIR spectra, changes in the intensity of the bands on irradiation relative to pristine samples occurred with the appearance of new bands. XRD analyses showed that the degree of ordering of the CR-39 polymer is dependent on the ion fluence. Changes of surface layer composition and an increase in the number of carbonaceous clusters produced important change in the energy gap and the surface wettability. The surface hardness increased from 10.54 MPa for pristine samples to 28.98 and 23.35 MPa for samples bombarded with Ar and He ions at the highest fluence, respectively. The physical and chemical properties of polymer electrolyte (PEO-$CdCl_2$) films irradiated with γ- rays were investigated by Raghu et al. (9). The degradation of the irradiated films was observed mainly due to chain scission/cross linking. The thermal stability and crystallinity were also found to decrease significantly. As a result of γ- ray irradiation a destruction of the polymer polypropylene lead to the formation of ketonic and alcoholic groups(10). In the polymer polyacetate, elimination of carbon dioxide was observed due to damage of the ester group. In polycarbonate, at the dose 10^6Gy, formation of phenolic group was observed due to cleavage of ester bonds. In PVC, The FTIR spectral studies indicated the formation of C=C bond with the simultaneous reduction in the concentration of C-Cl bond when irradiated to γ- radiation (10).

In the present work we investigated physical and chemical response of γ-radiation on CR-39 polymer, specially the modification in the optical, chemical and structural properties through UV/Vis spectrometry.

2. EXPERIMENTAL

The samples of about 30×30 mm size of CR-39 were cut from flat sheets of thickness 250 micron. These samples were put in polyethylene sachets and irradiated with γ- radiation from a ^{60}Co γ- source in air at room temperature at a dose rate 2.76 kGy/h at Bhabha Atomic Research Center, Mumbai (India). The samples were irradiated for various time periods to obtain the total accumulated γ- radiation doses as 1, 2, 5, 10, 20, 50, 117, 199 and 500 kGy respectively.

The optical absorption spectra were recorded at room temperature in the wavelength range 190 to 900 nm with the help of Shimadzu Double Beam Double Monochromator UV- Visible spectrophotometer (UV-2550) with a resolution of 0.05 nm. The samples were placed in the integrating sphere assembly ISR-240A attached with the spectrophotometer. The air was taken as reference. From these data the optical constants such as optical band gap (both direct and indirect) were determined.

3. RESULTS AND DISCUSSIONS

The unirradiated CR-39 samples are colorless. The visual observations of irradiated films indicate that the CR-39 samples above 50 kGy turn yellow with the increase of γ radiation dose and ultimately turn to dark brown at 500 KGy γ absorbed radiation dose. The CR-39 films also become brittle with increasing dose of γ radiation.

The UV- Visible absorption spectra of unirradiated and γ irradiated CR-39 films with a dose of 20, 50, 117, 199, and 500 KGy in the wavelength range 190 to 350 nm in terms of absorbance (α) Vs γ-radiation dose are shown in Figure 1. Since at lower doses (1, 2, 5 and 10 kGy) there was no significant difference in the spectra of irradiated CR-39 samples, therefore for simplicity their spectra are not shown.

It is clear from the Figure 1 that above 350 nm, no significant absorption occurs and a flat plateau region is observed for all radiation doses. Above 20 KGy dose of γ radiation the absorption bands within 250-350 nm range of all irradiated samples become broad and the tail of the absorption spectra shifts towards visible region from UV. An increase in absorbance at wavelength about 275 nm (hyper chromic shift) with the development of a new peak is also observed. All the above observations can be attributed to the formation of new

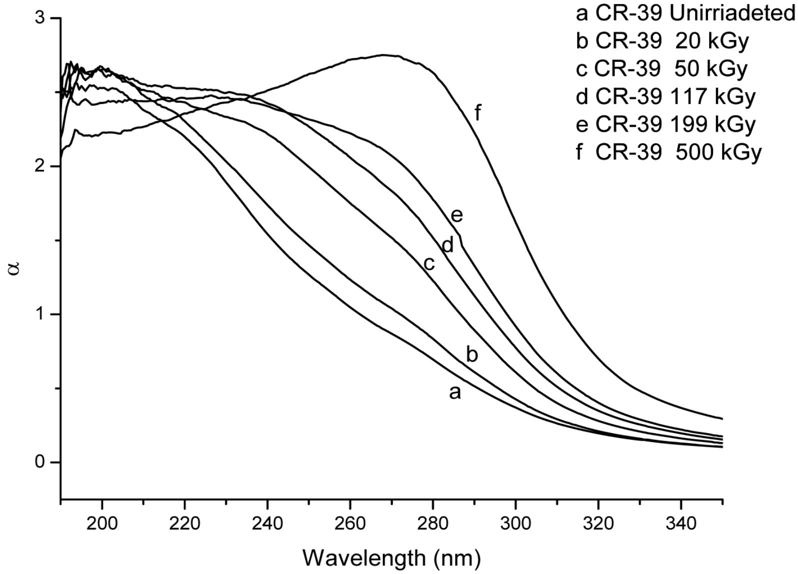

Figure 1: UV-Vis absorption spectra of unirradiated and irradiated CR-39 films.

chemical species as a result of energy deposition from the incident γ- rays. This energy deposition may lead to the ionization and excitation leading to the breaking of original bonds, chain scission, radical formation, cross linking etc. [2, 7, 8]. This in turn results in the formation of radicals, cations, anions, double/ triple bonds or aromatic species etc. The other possibility for red shift and coloration of CR-39 can be due to the increase in conjugation of double bonds (polyene formation) and formation of carbonaceous clusters with the increase in γ absorbed dose as reported earlier by other workers also [8].

3.1 Determination of Energy Band Gap

The study of optical absorption gives information about the band structure of solids. The insulators/ semiconductors are generally classified into two types (a) direct band gap materials (b) indirect band gap materials. In direct band gap materials the minimum of conduction band lies directly above the maximum of valance band in momentum space (the momentum of both is same). In indirect band gap materials the momentum of conduction band minimum and the valance band maximum are not the same. In direct band gap material, electrons from the minimum of conduction band can recombine with holes at the maximum of valance band without any exchange in momentum. The energy of the recombination across the band gap will be emitted in the form of a photon of light. This is a radiative transition. In indirect band gap materials the transition across the band gap does not conserve momentum and is forbidden. This recombination occurs with the mediation of a third body, such as a phonon or a crystallographic defect, which allows the conservation of momentum. This recombination often releases band gap energy as phonon instead of photon. Davis and Shilliday (11) showed that near the fundamental band edge, both direct and indirect transitions occur. These can be determined by plotting $\alpha 1/2$ and α^2 against frequency where α is called absorbance. According to Thutupalli and Tomlin (12) the direct and indirect band gap (Eg_d and Eg_i respectively), of a semiconductor are related to the absorbance (α) as follows:

$$(n\alpha h\nu) = A\,(h\nu - Eg_d)^{1/2}$$

$$(n\alpha h\nu) = B\,(h\nu - Eg_i)^{2}$$

Where $h\nu$ is the photon energy, n is the refractive index and A and B are constants. These relations have also been found to hold good for polymers also (13).

For the determination of nature and width of direct and indirect band gaps $(\alpha h\nu)^2$ and $(\alpha h\nu)^{1/2}$ were plotted as a function of photon energy ($h\nu$)

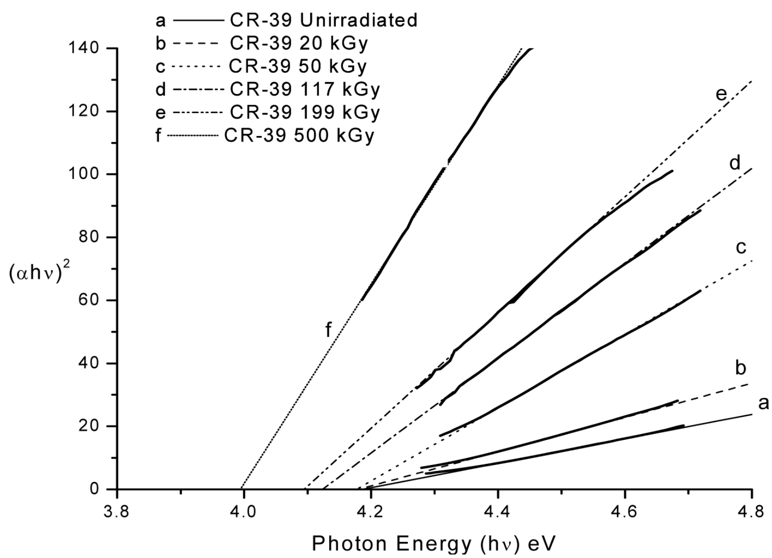

Figure 2: $(\alpha h\nu)^2$ versus photon energy ($h\nu$) eV curves of unirradiated and irradiated CR-39films.

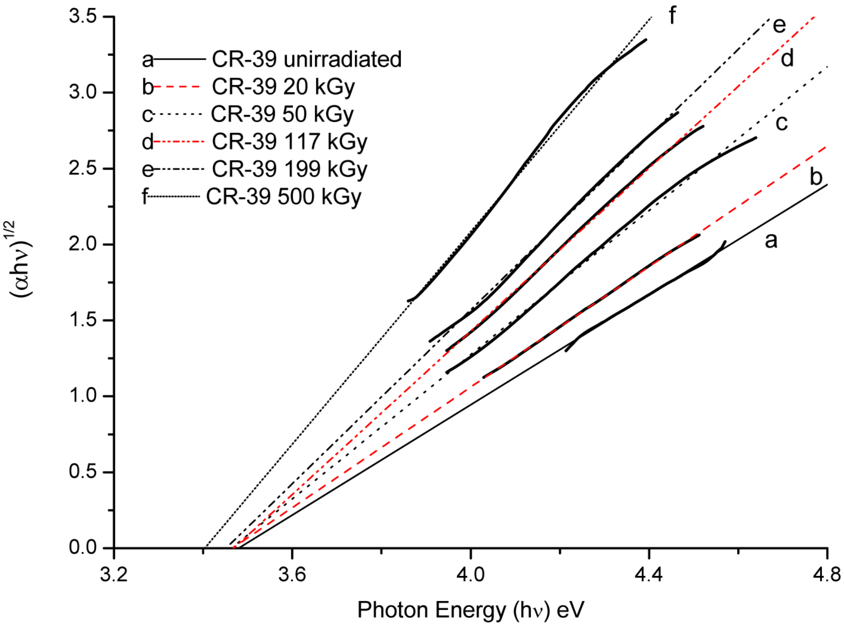

Figure 3: $(\alpha h\nu)^{1/2}$ versus photon energy (hν) eV\ curves of unirradiated and irradiated CR-39films.

respectively, taking into account the linear portion of the fundamental absorption tail of the UV- visible spectra as shown in Figures 2-3. The direct band gap energies were determined by extrapolating the linear portions of the $(\alpha h\nu)^2$ vs. hν (photon energy) curves, from the intercepts of the best fit lines on hν axis as shown in Figure 2.

Table 1: Direct and indirect optical band gaps of unirradiated and irradiated CR-39films.

γ- radiation **dose (kGy)**	**Band Gap (eV)**		**Regression Coefficient 'R'**
	Direct	**indirect**	
Unirradiated	4.23	3.52	0.99
20	4.19	3.50	0.99
50	4.18	3.46	0.99
117	4.15	3.42	0.99
199	4.12	3.35	0.99
500	3.98	3.3	0.99

The indirect band gaps were obtained from the $(\alpha h\nu)^{1/2}$ versus $(h\nu)$ photon energy curves in the similar manner as shown in Figure 4.

These values along with their slandered errors have been determined for unirradiated and CR-39 samples irradiated to different doses of γ- radiation and the values of direct and indirect band gaps are presented in Table 1.

The magnitude of regression coefficient, have been found to be greater than 0.99 for the fitted lines as shown in Figures [2–3] for the determination of absorption edge, direct band gap and indirect band gaps. This in turn clearly indicates the simultaneous existence of direct and indirect band gap in CR-39 polymer with decreasing tendency with the increasing γ- radiation dose. The values of indirect band gap have been found to be lower than the corresponding values of the direct band gap in the CR-39 polymer subjected to γ- radiation.

3.2 Conjugation Length:

From the abscissas of $(\alpha h\nu)^{1/2}$ versus photon energy $(h\nu)$ plots in Figure 3 of irradiated CR-39 the number of carbon atoms per conjugation length has been calculated using Robertson's and O'reilly relation (13, 14) given by equation (1)

$$N = \frac{2\beta\pi}{E_g} \tag{1}$$

Where, N is the number of carbon atoms per conjugation length for a linear chain polymer. 2β is the band structure energy of a pair of adjacent π site. The value of β is taken to be -2.9 eV as it is associated with π- π^* optical transition in C=C structure. E_g was taken as the lower value of band gap i.e. the indirect

Table 2: The number of carbon atoms in conjugation calculated from eq. 1 along with the data number of carbon atoms (M) in cluster.

γ- radiation dose (kGy)	No. of carbon atoms in conjugation (N) calculated from eq. 1	Number of carbon atoms (M) in cluster
500	~6	108
199	~5	104
117	~5	101
50	~5	98
20	~5	96
Unirradiated	~5	96

energy band gap. The number of carbon atoms in conjugation (N) calculated from above equation in the present work at different doses of γ -radiation is given in Table 2.

It is evident from Table 2 that the results calculated from eq. 1 show increase in the C=C conjugation length as reported earlier also (2).

3.3 Carbon Cluster Size:

It is also understood (Fink et al.) (3) that the Robertson's equation underestimates the cluster size in the irradiated polymers. They have accordingly assumed the structure of the clusters to be buckministerfullerene, i.e. comprising of C_{60} rings instead of $C_{6,}$ arriving at the relation

$$E_g = \frac{34.3}{\sqrt{M}},$$

Where M is the number of carbon atoms per cluster. The above relation can be used to obtain the number of carbon atoms per cluster in irradiated polycarbonate. Thus,

$$M = \frac{(34.3)^2}{E_g^2} \quad (2)$$

CONCLUSIONS

The visual inspection of CR-39 films exposed to γ radiation show yellowing of the samples with the increase of γ absorbed dose. UV-Vis spectrometric studies of virgin and γ- irradiated CR-39polymer reveals the coexistence of direct and indirect band gaps simultaneously. The indirect band gap values are found lower as compared to the corresponding values of direct band gap in the unirradiated and γ- irradiated CR-39 polymer. Both types of the optical band gap energies have decreasing tendency with the increasing γ radiation dose. The intensity patterns of various bands appearing in the UV-Vis and FTIR spectra of γ irradiated CR-39 show the structural modifications that correspond to formation of π conjugation sites of various lengths. The number of carbon atoms per conjugation increase with the increase of γ absorbed dose. It is also clear that the high value of energy deposition results in reorientation of polymeric molecules leading to the formation of carbon clusters accompanied with increase in size (8) with the increase in γ radiation dose.

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Study of Antibacterial Activity of *Leaf Extracts of Dalbergia Sisso* (*Roxb*.)

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Abstract Antibacterial activity of ethanolic, distilled water and methanol extract of the leaves of *Dalbergia Sisso (Roxb.)* were studied against *Escherichia coli* and *Bacillus licheniformis* by agar well diffusion method. Results obtained showed that the growth of both *E.coli* and *B.licheniformis* were inhibited by all the three extracts of dried *Leaf Extracts of Dalbergia Sisso* (*Roxb.*). The antibacterial activity of these extracts against selected bacterial stains depends on the type of solvent used for extraction. The present study revealed that *Leaf Extracts of Dalbergia Sisso (Roxb.)* can be exploited for new potent antibacterial agents.

Keywords: Dalbergia Sisso, World Health Organization1

1. INTRODUCTION

Ancient time, in search for rescue for their disease, the people looked for the drugs in nature. The beginning of the medicinal plants use were instinctive, as in the case with animals. (Stojanoski, 1999). In view of the fact that at that time there was no sufficient information either concerning the reason for the illness or concerning which plant and how it could be utilized as a cure, everything was based on the experience. In Ancient time, the reason for the usage of specific medicinal plants for treatment of certain diseases was being discovered thus, the medicinal plants usage gradually abandoned the empiric framework(Kelly, 2009).

While the old people used medicinal plants primarily as simple pharmaceutical forms- infusions, decoctions and macerations. In the middle ages, particularly between 16th and 18th centuries, the demand for compound

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drugs was increased (Tpolak, 2005). The compound drugs comprised medicinal plants along with drugs of animal and plant origin. If the drug compound as produced from a number of medicinal plants, rare animals, and minerals, it was highly valued and sold expensively (Bojadzievski, 1992).

Early 19th century was a turning point in the knowledge and use of medicinal plants. The discovery, substantiation and isolation of alkaloids from poppy (1806), quinine (1820), pomegranate (1878) and other plants then the isolation of glycosides marked the beginning of scientific pharmacy (Lukic, 1985). Herbal medicine, also called botanical medicine or phytomedicine, refers to using a plant's seeds, berries, roots, leaves, bark or flowers for medicinal purposes (Abeloff, 2008). Plants have been used for medicinal purpose long before recorded history. Indigenous cultures (such as African and Native American) used herbs in theri healing rituals, while others developed traditional medicinal system (such as Ayurveda and Traditional Chinese Medicine) in which herbal therapies were used. Researchers found that people in different parts of the world tended to use the same or similar plants for the same purpose (Altschuler et. al., 2007).

India has a rich heritage of traditional medicine which formed the basis of health care since earliest days of mankind. A large number of herbs or medicinal plant parts are used in several formulations for the treatment of many diseases caused by microbes. Herbal medicine is still the main stay of about 75-80% of the whole population, mainly in developing countries. The World Health Organization (WHO) estimated that almost 80% of the people worldwide rely on plant based medicines for their primary health care needs (Famsworth, 1985) and India happens to be the largest user of traditional medical cure, using 7000 plant species.

Medicinal plants represents a rich source of antimicrobial agents. Plants are used medicinally in different countries and are a source of many potent and powerful drugs (Srivastava et. al., 1996). A wide range of medicinal plant parts (root, stem, leaf, flower, fruit, twigs, etc.) extracts are used as raw drugs as they possess many medicinal properties. Some of these raw drugs are collected in smaller quantities by the local communities and folk healers for local use while many raw drugs are collected in larger quantities and traded to herbal industries as raw material (Uniyal et. al., 2006). There are several reports on the antimicrobial activity of different herbal extracts in different regions of the world (Parekh et. al., 2005), but vast majority have not been adequately evaluated (Balandrin et. al., 1985)..

The increasing failure of chemotherapies and antibiotic resistance exhibited by pathogenic microbial infections agents have led to the screening of several medicinal plants for their potential antimicrobial activity (Rich-Krc et. al., 1996; Martins et. al., 2001). Antibacterial properties of various plants parts have been well documented for some of the medicinal plants for the past two decades (Leven et. al., 1979).

In India the herbal remedies is so popular that the government of India has created a separate department (AYUSH) under the Ministry of Health and Family Welfare. The National Medicinal Plants Board was also established in 2000 by the Indian government in order to deal with the herbal medicinal system (Bottcher, 1965).

Virulent strains of Gram negative bacterial *E.coli* can cause gastroenteritis, urinary tract infection and neomatal meningitis. Some strains of *E.coli.* bacterial may also cause severe anemia or kidney failure, which can lead to death (http:www.m.webmd.com/) Gram positive bacteria *B.licheniformis* is commonly associated with food spoilage and poisoning (Peopo et. al.,2003). Food poisoning by *B.licheniformis* is characterised by diarrhea and vomiting.

Dalbergia Sisoo Roxb. (Shisham, Sisoo, Tally) internationally premier timber species of the rosewood genus *Dalbergia. Sisoo* is reported a stimulant used in folk medicine and remedies (Oxford Dictionaries Online, 2014). It is used in conditions like emesis, ulcers, leucoderma, dysentery, stomach troubles and skin diseases (Ali, 2007). Pharmacological investigations indicated that its leaves posses different medicinal properties as antimicrobial (Mukhtar et. al., 2006), anti-inflammatory (Prabu et. al., 2006), antioxidant (Qjewale, 2005), antidiarrhoel (Majumdar et. al., 2005), antifertility (Ucendu and Leek, 1999), antiplamodial (Beldjoundi et. al., 2003), larvicidal and mosquito repellant activity (Ansari et.al., 2008).

But very little studies have been done on the antibacterial activity of plant extracts of *Dalbergia Sisso (Roxb.)*. Keeping in view the importance of different types of infections caused by bacteria the present study was designed to find out the antibacterial potentiality of *Leaf Extracts of Dalbergia Sisso (Roxb.)* against selected stains of bacteria.

2. MATERIALS AND METHDOS

2.1 Collection of Plant Material

The leaves of *Dalbergia Sisso (Roxb.)* were purchased from the local herb shop of Patiala district of Punjab (India). The plant was identified, confirmed and authenticated (Jain, 1999).

2.2 Sample Preparation

The leaves of *Dalbergia Sisso (Roxb.)* were thoroughly washed and dried in hot air oven at 100°C for about 1hr. The dried sample was then grinded into fine powder using an electric grinder.

2.3 Extract Preparation

The extracts of the leaves of *Dalbergia Sisso (Roxb.)* were prepared in ethanol, distilled water and methanol by following the methodology of Alam et.al., 2010, 25g of finely grinded, dried root powder was extracted using soxhlet apparatus, using 150ml of solvent and the extract was done for about 36-48 hrs. at 25±2°C. Solvent was removed under reduced pressure and the residues were collected and stored and further dried in vacuum desicator over anhydrous calcium chloride to get a dry solid of extract for further study.

2.4 Phytochemical Analysis

The crude extracts were analysed for the presence of alkaloids, carbohydrates, proteins, steroid glycosides, polyphenolic compounds, saponine, tannins and flavonoids (Oloyede, 2009).

2.5 Procurement of Microorganisms

B.licheniformis and *E.coli* species were collected from department of Biotechnology and the pure cultures of bacteria were maintained on nutrient agar slants for their vegetative growth. The cultures were maintained in incubator for use and regularly checked for contamination, and the periodic transfers were made aseptically.

2.6 Culture of Test Microbes

For the cultivation of bacterial, Nutrient Agar Medium (Beef extract - 1.0 g, Yeast extract - 2.0 g, Peptone - 5.0 g, NaCl- 5.0 g, Agar - 15.0 g, distilled water 1 L) were prepared and sterilized at 15 lbs pressure and 121°C temperature for 25-30 min. Agar rest plates were prepared by pouring approximately 15ml of Nutrient Agar medium into the Petri dish under aseptic conditions.

2.7 Agar Well Diffusion Method

The ethanol, distilled water and methanol extract of leaves of seeds of ***Dalbergia Sisso (Roxb.)*** were tested by Agar Well Diffusion method (Alam et.al., 2010) (4 mm) holes were punched aseptically in nutrient agar plate by using a sterilized cork borer. The cotton swabs were dipped into the broth culture of the test organisms and were gently squeezed against the inside of the tube to remove excess fluid. *E.coli* and *B.licheniformis* were swabbed on Agar plates. Swabbing was done in outside diameter of the plates. The plates were allowed to dry for about 5 minutes. Then the extracts of leaves of ***Dalbergia Sisso (Roxb.)*** of concentrations (100%) were added into wells of Petri plates.

Pure solvents were used as control whereas gentamycin was used as reference for bacterial species. The plates were incubated at 37°C for 24 hrs. The zones of inhibition were measured in millimeters (mm), using Vernier caliper. The zone size was recorded and all the cultures were discarded by autoclaving.

3. RESULTS AND DISCUSSION:

The ethanol, distilled water and methanol extract of *Leaf Extracts of Dalbergia Sisso (Roxb.)* were tested for alkaloids, steroid glycosides, saponins, tannins and flavonoids, and results are reported in table 1 and the results of zones of inhibition of these extracts with their 100% concentration and standard (gentamycin) against the tested bacterial stains *B.licheniformis* and *E.coli* are reported in table 2.

Table 1: The observation of the Phytochemical tests of different extracts of the *Leaf Extracts of Dalbergia Sisso (Roxb.)*

Test	Ethanol Extract	Distilled Water Extract	Methanol Extract
Alkaloids Wagner's reagent (Dark Brown coloured ppts)	–	+	+
Steroid glycosides Conc. H_2SO_4 test (Reddish Brown color)	+	+	+
Saponins Foam test (Presence of foam at surface)	+	+	+
Tannins Ferric Chloride test (Dark Blue or Bluish Black product)	+	+	+
Flavonoids Sodium Hydroxide test (Appearance of Yellow color)	+	+	+
Glycosides Chloroform extract glacial acetic acid $FeCl_3$ and H_2SO_4 (Blue color appears in Acetic Acid Layer)	+	+	+

The zones of inhibition of solvent control were nil and of standard (gentamycin) the zone of inhibition for *B.licheniformis* and *E.coli* were 24mm and 22 mm respectively. The zones of inhibition observed for the difference extracts of *Leaf Extracts of Dalbergia Sisso (Roxb.)* (table 2) at 100%

Table 2: The zones of inhibition with different extracts of the Leaf Extracts of Dalbergia Sisso (Roxb.)

Test organism	Solvent extract	Zone of inhibition	Control
Bacilus Licheniformis (B.licheniformis)	Ethanol	20 mm	—
	Distilled Water	—	—
	Methanol	18 mm	—
	Standard (Gentamycin)	24 mm	—
Escherichia coli (E.coli)	Ethanol	22 mm	—
	Distilled Water	15 mm	—
	Methanol	15 mm	—
	Standard (Gentamycin)	22 mm	—

concentration were quite close to the zone of inhibition shown by standard (gentamycin) for tested organisms. Thus the growth of both *B.licheniformis* and *E.coli* were inhibited to a good extent by all extracts of *Leaf Extracts of Dalbergia Sisso (Roxb.)*.

Therefore, it is recommended that extract and purification of bioactive compounds present in *Dalbergia Sisso (Roxb.)* are valuable in the preparation of drugs of different kinds. The assessments of various effects of such compounds on the animal and human health are required for future studies.

CONCLUSION

The present study reveals the presence of many secondary metabolites in the root extracts of *Dalbergia Sisso (Roxb.)*. It has also confirmed that the root extracts of *Dalbergia Sisso (Roxb.)* could be used for the treatment of various infections. The root extracts of *Dalbergia Sisso (Roxb.)* have potent antibacterial activity when compared with conventionally used drugs and is almost equipotent to the standard (gentamycin) antibacterial drug. The results lend credence to the folkloric use of the root of *Dalbergia Sisso (Roxb.)* in treating bacterial infection and show that *Dalbergia Sisso (Roxb.)* may be explored for its further phytochemical profile to identify the active constituents responsible for their use as potent antibacterial agents.

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