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PHARMACOGNOSTICAL AND PHARMACEUTICAL CHARACTERISATION OF DELONIX REGIA - A NOVEL MATRIX FORMING NATURAL POYMER

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ABSTRACT

Herbal medicinal plants are said to be the nature‘s gift to mankind, since they have been of long age remedies for human diseases. The present study was undertaken to isolate gum from the seeds of Delonix regia linn, to explore its use as a Pharmaceutical exicipient. The isolated gum was evaluated for various Pharmacognostical parameters and physico-chemical characterization. The loss on drying, ash value and microbial load were well within the official limits. Qualitative phytochemical analysis of these extracts revealed the presence of flavonoid, saponins, carbohydrates and tannins in some extracts, The explored result suggest that various bioactive compounds of seed can be used for curing various diseases .This study elucidated the physical, thermal, sorption and functional properties of a gum obtained from the seed of Delonix regia . Scanning electron microscopy (SEM), Particle size analysis, X-ray powder diffraction (XPRD), Differential scanning colorimetry (DSC), and Fourier transmittance infra red (FTIR), were used to characterize the gum sample which can be used further for the formulation development.

Keywords: Delonix regia seed polymer (DRSP), phytochemical screening, Differential scanning calorimetry, swelling index.

INTRODUCTION

Traditional medicines play an important role in health services around the globe. About three-quarters of the world population relies on plants and plant extracts for thousands of year in healthcare. Nowaday’s person prefers plant based medicines over synthetic medication for the treatment of different disease because of their safety as well as economy. The rational design of novel drugs from traditional medicine offers new prospects in modern healthcare. Herbal medicines are particularly used by the traditional practitioners since the ancient time but they do not have scientific data. [1]

Delonix regia is a flamboyant tree native to Madagascar, its seeds have traveled the world and the species is now common through the tropical cities [2]. It is widely cultivated and may be seen adorning avenues, parks and estates in tropical cities throughout the world..Planted as avenues in garden and and on roads throughout India. It is commonly known as ‘Gulmohar’ in Hindi and Marathi. [3]

The plant Delonix regia (family: leguminosae, sub family: Fabaceae) some time known as royal Poinciana, may flower plant or Flamboyant, many branched, broad, spreading, flat crowned deciduous tree and well known for its brilliant display of red-orange bloom, literally covering the tree from May to June [2]. The Delonix regia will provide fullest flowering and best growth when planted in full sun location [4].

The flowers have a typical caesalpinioidae structure, with one larger petal and 10 stamens. The upper petal

has streaks of yellow and white and the stamens are prominent and curved slightly downward [2]. When the tree becomes leafless, fruits ripen in August to October. Seed pods (large, flat, 40 to 70 cms by 2.5 to 4 cms in size, compressed, hard, brown or black when ripe) were collected in September to October. 20 to 30 seeds in distinct cavities, brown, with a dark ridge, hard bony testa, oblong, 1.5 to 2 cms in length
The literature survey reveals that Delonix regia contain galactomannose, ß-sitosterol, saponins, alkaloids, carotene, hydrocarbons phytotoxins, lectins and flavonoids. Delonix regia also *contains* tannins, phenolic compounds, glycosides, sterols, and triterpenoids. The decoction of the leaves is traditionally used in treating gastric problems, body pain, and rheumatic pains of joints [5,6] Traditionally Delonix regia plant is used as anthelmintic, antimicrobial, anticancer, antirheumatic, antimalarial, antioxidant, hepatoprotective activity, antiulcer effect and anti-diabetic activity. [7]

MATERIALS AND METHODS

Collection of Plant material: The seed pods of *Delonix regia* were collected in the month of May from the surrounding fields of Puducherry.

Isolation of the gum from seeds of Delonix regia

Method 1: The pods of Delonix regia, family-Fabaceae were collected and these pods were imbibed in the water for an overnight to separate the seeds from the pods. The seeds mainly contain the three parts seed kernel, endosperm,and dicotyledon. The seeds (500g) were boiled in the distilled water for 3 h until the seed kernels were swelled which was then removed by the hands. The gum part was separated from the yellow dicotyledons as shown in figure1A. The gum portion was dried in an oven at 45°C for 12 h and then was grounded in the multimill. The resulting powder was passed through 60 # sieve. [8]

Method 2**:** The seeds of the higher plant Delonix regia were collected and subjected to boiling for 5-6 h. Seed coat were removed and the mesosperm was separated which was then transferred into beaker containing distilled water and boiled again to get the viscous mass. This viscous polymeric mass was then allowed to dry in an oven till it dried completely. The dried polymeric material was then subjected to size reduction in multimill and sieved through sieve shaker using 60 # sieve to get the desired particle sizeas shown in figure 1B. [9]

Pharmacognostic Evaluation

Extractive value determination **[10]:** Coarsely powdered air-dried material 4 g was placed in a glass stoppered conical flask and macerated with 100 ml of solvents (water, methanol, and chloroform) shaking frequently, and then allowing it to stand for 18 hours. Filter it rapidly through whatman No. 1 filter paper, taking care not to lose any solvent. Transfer 25 ml filtrate to flat- bottom dish and evaporate solvent on a water bath. Dry at 105 ^{o} C for 6 hours, cool in a desiccator for 30 minutes and weigh it immediately. Calculate the content of extractable matter in % of air-dried material.

Ash values**:** Ash values such as total ash, acid insoluble ash, water-soluble ash, and sulfated ash were determined according to Indian pharmacopoeia. For determination of ash values, powder prepared sifted through sieve no. 20 and following tests were performed.

Total ash**:** About 3 g each of powdered parts were accurately weighed and taken separately in silica crucible, which was previously ignited and weighed. The powder was spread as a fine layer on the bottom of crucible. The powder was incinerated gradually by increasing temperature to make it dull red hot until free from carbon. The crucible was cooled and weighed. The procedure was repeated to get constant weight. The percentage of total ash was calculated with reference to the air-dried powder.

Acid insoluble ash: The ash obtained as described above was boiled with 25 ml of 2N HCl for 5 minutes. The insoluble ash was collected on an ash less filter paper and washed with hot water. The insoluble ash was transferred into a crucible, ignited and weighed. The procedure was repeated to get constant weight. The percentage of acid insoluble ash was calculated with reference to the air-dried drug.

Water soluble ash: The ash obtained as described for the total ash, was boiled for 5 minutes with 25 ml of water. The insoluble matter was collected on ash less filter paper and washed with hot water. The insoluble ash was transferred into silica crucible, ignited for 15 min. and weighed. The procedure was repeated to get a constant weight. The weight of insoluble matter was subtracted from the weight of total ash. The difference of weight was considered as water-soluble ash. The percentage of water-soluble ash was calculated with reference to air-dried parts respectively.

Sulfated ash: A silica crucible was heated to red for 10 min. and was allowed to cool in a desiccator and weighed. A gram of substance was accurately weighed and transferred to the crucible. It was ignited gently at first, until the substance was thoroughly charred. Then the residue was cooled and moistened with 1 ml of concentrated sulfuric acid, heated gently until white fumes are no longer evolved and ignited at 800 ^{o} C ± 25 ^{o} C until all black particles have disappeared.The ignition was conducted in a place protected from air currents. The crucible was allowed to Cool. A few drops of concentrated sulfuric acid were added and heated. Ignited as before and was allowed to cool and weighed. The operation was repeated until two successive weighing do not differ by more than 0.5 mg.

Micro chemical tests [11]: Powder of Delonix regia seed was treated with chemicals to observe the colour change under ordinary light. Fine powder 1 g was treated with 5ml of chemicals like, HCl, H_2SO_4, HNO_3, Acetic acid, Ferric chloride and 10% NaOH.

Preliminary phytochemical screening [12]: A preliminary phytochemical screening of Delonix regia powder extract was carried out for the detection of various phytoconstituents. The presence of carbohydrate (Molisch's test), reducing sugar (Fehling's solution), alkaloid (Dragendorff reagent and Mayer's reagent), flavonoids (Shinoda test), steroids (Liberman Burchard test), and terpenes (Vanillin sulfuric acid reagent) were analyzed.

Pharmaceutical evaluation [13-17]

Acid value: 10 g sample of each was dissolved in 50 ml mixture of equal volume of ethanol (95%) and ether previously neutralized with 0.1 M potassium hydroxide solution to phenolphthalein. After addition of phenolphthalein (1 ml), sample solution was titrated with 0.1 M potassium hydroxide until it remained faintly pink after shaking for 30 min. Acid value was calculated by the formula,

Acid Value = 5.61 n/W,

Where n = number of ml of 0.1 M potassium hydroxide required and W = weight in grams of substance

Relative solubility: 6 g gum sample in 10 ml organic solvent and 3 g gum sample in 10 ml of different pH buffer was placed in a test tube mounted on a water-bath shaker for 24 h. Then 2 ml of each was transferred to a porcelain dish and the solvent was evaporated. Half of the weight gain of porcelain dish after complete solvent evaporation was taken as solubility per ml of GC and GD in that particular solvent/solution.

pH determination: This was done by shaking a 1%w/v dispersion of the sample in water for 5 min and the pH determined using a pH meter (Corning, model 10 England). The data presented here is for triplicate determinations.

Viscosity Determination: The viscosity of 1% (w/v) DRG solution was measured according to the USP specification, using Brookfield DV-E Viscometer

Swelling index: About 1 gm of DRG powder was accurately weighed and transferred to a 100 ml measuring cylinder. The initial volume of the powder in the measuring cylinder was noted. The volume occupied by the gum sediment was shaken gently and set aside for 24 h. The volume occupied by the gum sediment was noted after 24 h. Swelling capacity of DRG was expressed in terms of swelling Index. Swelling Index was expressed as a percentage and calculated according to the following equation:

$SI= [Xt- Xo)/Xt] \times 100.$

Where; Xo is the initial height of the powder in graduated cylinder and Xt denotes the height occupied by swollen gum after 24 h.

Water retention capacity: The contents from the measuring cylinder from the above test were filtered through a muslin cloth and the water was allowed to drain completely into a dry 100 ml graduated cylinder. The volume of water collected was noted and the difference between the original volume of the mucilage and the volume drained was taken as water retained by the sample referred as water retention capacity or water absorption capacity of the polysaccharide.

Moisture sorption capacity: Moisture sorption study was performed using programmable environmental test chamber (Remi Labs, Mumbai, India). One gram of powdered DRG was taken in a Petri dish and spread uniformly. Then it was kept in programmable environmental test chamber 37 ± 1°C and 100% relative humidity for two days. The moisture sorption was calculated by recording weight difference of the sample before and after exposure to programmable environmental test chamber.

Hydration capacity: Powdered DRG was taken in the 15 mL tarred centrifuge tube. Then 10 mL of distilled water was added to it and allowed to centrifuge for 10 min. After the centrifugation process the tarred centrifuge tube was taken out and inverted to remove the supernatant. The decanted tube then weighed on digital balance (Shimadzu, Japan).

Angle of repose: The angle of repose was determined by the funnel method. The accurately weighed powder was taken in a funnel. The height of a funnel was adjusted in such a way that its tip just touched the apex of the heap of the powder. The powder was allowed to flow through the funnel freely on to the surface. The diameter of the powder heap was measured and angle of repose was calculated using the following equation:

$$\theta = \tan (h/r)$$

Where θ = Angle of repose, h = weight of powder heap and r = radius of powder heap.

Density: The loose bulk density (LBD) and tapped bulk density (TBD) of DRG powder was determined. Powdered gum (2g) was poured into calibrated measuring cylinder (10 ml) and noted initial volume. Then the cylinder was allowed to fall under its own weight onto the hard surface from the height of 2. 5 cm at 2s intervals. The tapping was then continued until no further change in volume was noted. LBD and TBD were calculated using the following equations:

LBD = Weight of the powder/volume of the packing.
TBD = Weight of the powder/tapped volume of the packing.

Microbiological properties

Microbial load

Preparation of inoculums: 1g powder of Delonix regia gum was suspended in 10 ml of sterile water (inoculum). 1 ml of inoculum was transferred to 99 ml dilution blank (sterile water) which was diluted inoculum.

Plate count technique: Inoculum (1 ml) and diluted inoculum (1 ml) were transferred to separate petridishes 9 to 10 cm in diameter. After addition of both the inoculum to the plate, 20 ml of agar medium (40-45°C) was poured into the each plate. Both the plates were gently rotated for through distribution of inoculum throughout the medium and solidified as shown in Table:1

Drug-excipient compatibility studies: This study has been done to check whether there is any compatibility related problems are associated with drug and the excipients used for the formulation the drug and excipients must be compatible with one another to produce a product that is stable, efficacious, attractive, and easy to administer and safe.

If the excipients are new and not been used in formulations containing the active substance, the compatibility studies are of paramount importance. Thermal analysis, TLC, HPLC, FTIR, can be used to investigate and predict any physicochemical interactions between components in a formulation and can therefore be applied to the selection of suitable chemically compatible excipients.

Fourier Transform Infra-Red Spectroscopy (FTIR): The pure drug and physical mixture of drug and polymers were subjected to IR spectroscopic study using FT-IR spectrophotometer (IRAffinity-1, Shimadzu). The spectra were scanned over the wave number range from 4000 – 400 cm-1.

Differential Scanning Calorimetry: Thermogram of Natural polymer was employed (`DSC-Shimadzu 50) for the determination of glass transition temperature (Tg). About 2 mg of sample was placed in aluminium pan and scanned over a temperature range of 25-250 ^{0} at the rate of 5 ^{0}/min. Each sample was subjected to three consecutive DSC scans. Tg was determined by the midpoint of endothermic changes associated with the glass transition.

X-Ray Diffraction Studies (XRD): Powder XRD patterns of natural polymer was recorded using diffractograms (PW 1140, Mettler Toledo, USA) and Cu-kα radiation. Diffractograms were run at a scanning speed of 2°/mm and a chart speed of 2°/2 cm per 2 θ.

Scanning electron microscopy: The SEM photographs of DRG were obtained by scanning electron microscope (JSM 6390, JEOl, USA) with 10 kV accelerating voltage. to 350°C in nitrogen atmosphere.

Micromeritic measurements

Particle size distribution: Particle size distribution was determined by integrated light scattering using a Mastersizer 2000 (Malvern Instruments Ltd., Malvern, UK). The prepared powders were analyzed in duplicate.

The instrument used the principle of Fraunhofer diffraction where a parallel, monochromatic beam of laser light (red light = 633 nm) illuminates the polymer. The light diffracted by the polymer gives a stationary diffraction pattern regardless of the particle movement. As particles enter and leave the illuminated area, the diffraction pattern changes,

always reflecting the instantaneous size distribution in the illuminated area. The particle diameter ranges were performed at room temperature (20 ^{o} C). A 45 mm focal lens was used for the measurements.

RESULTS AND DISCUSSION

Results for extractive value, and ash analysis of seeds were recorded in Table 2. Extractive value in methanol was not much different than the extractive value in water, but nature of residual and filtrate colour was quite different than water as extractive solvent. Among selected solvents, chloroform extracted less matter from the plant powder, and filtrate colour was also different as compared to water and methanol. Total ash was higher than the acid insoluble ash, and water-soluble ash. Extract of seeds (water, methanol, and chloroform) were qualitatively analyzed for the major chemical groups (carbohydrate, protein, alkaloid, steroids, flavanoid, terpenoids, glycoside, saponin, tannin and fixed oil) and results are recorded in Table 3. Powders of seed were treated with concentrated acids, ferric chloride solution, base and colour changes in the powder were recorded in Table 4.

Extractive value, ash value, microchemical tests, and the qualitative evaluation of extract for the phytochemical groups are used for the characterization of botanical drug, and these are the preliminary steps of quality control for herbal drugs. Biological activity of crude drug is mainly due to the active chemical constituents, and the constituent may be soluble in different polar, semi polar and nonpolar solvents. Methanol and water showed highest extractive values, and both are able to extract most of phytoconstituents from powder. Ash value of medicinal plants reflects the carbonate, phosphate, oxides, silicate, and silica. Moreover the total ash of a crude drug also reflects the care taken in drug preservation, and the purity of crude and the prepared drug. Acid insoluble ash reflects the calcium oxalate content of the drug.

In the present investigation considerable amount of total ash was noticed in seed, findings can be employed as quality parameter to evaluate Delonix regia biomass for any adulteration. Micro chemical tests are used to characterize the crude drug. Among employed chemical test, seeds of Delonix regia *produced* noticeable colour with concentrated acids, it can be an important character to ascertain genuineness of the powdered drug. Phytochemical profiling of methanol, choloroform and water extract of DRSP emerged with noticeable results for carbohydrate, flavanoid, saponin and fixed oil. Like alkaloids, tannins, terpenoids, glycoside and tannin were absent in DRSP. Such outstanding phytochemical screening results can be good tool for identification of DRSP biomass particularly when grinded to fine powder.

Results of the characterization and physicochemical evaluation of investigated are shown in Table 5. Very low acid value of DRSP indicates its better chemical stability. It exhibited good solubility in almost all the organic solvents except chloroform, and greater solubility in alkaline compared to acidic pH.

A 1% w/v suspension of DRSP in water gave a pH of 7.7 while that of tragacanth was 5.3. The near neutral pH of DRSP implies that when used in uncoated tablets, it may be less irritating to the gastrointestinal tract. It may also find useful application in formulation of acidic, basic and neutral drugs. Knowledge of the pH of an excipient is an important parameter in determining its suitability in formulations since the stability and physiological activity of most preparations depends on pH.

The swelling characteristic of DRSP (Delonix regia seed polymer) was studied in different media; 0.1N hydrochloric acid, phosphate buffer (pH 7.4) and water. The swelling was highest in water followed by phosphate buffer and least in 0.1N HCl pH. Generally, the results show that DRSP has high swelling index suggesting that the gum may perform well as binder/disintegrant/ matrixing agent. The gum is a pH responsive polymer, it is therefore a "smart polymer," and may find application in controlled release dosage formulations. The relatively higher swelling index obtained for DRSP at pH 7.4 implies that unlike tragacanth, the gum may be useful as a matrix former in controlled drug release. Swelling is a primary mechanism in diffusion controlled release dosage form.

The moisture content of DRSP was low, suggesting its suitability in formulations containing moisture sensitive drugs. Given suitable temperature moisture will lead to the activation of enzymes and the proliferation of micro organisms, thereby affecting the shelf life of most routine formulations. It is important to investigate the moisture content of a material because the economic importance of an excipient for industrial application lies not only on the cheap and ready availability of the biomaterial but the optimization of production processes such as drying, packaging and storage.

The bulk and tapped densities give an insight on the packing and arrangement of the particles and the

compaction profile of a material. The compressibility index and angle of repose of DRSP was 23.22% and 37.6.° respectively, implying that DRSP has a fair flow with moderate compressibility, unlike tragacanth with a very poor compressibility index and angle of repose. This is important in scale up processes involving this material as an excipient in a pharmaceutical formulation. Modification of formulations containing this natural polymer for the improvement of flow properties during process development will therefore be minimal compared to tragacanth (e.g.,inclusion of glidants or agents to aid in feeding).

Fourier Transform Infrared (FTIR) Spectroscopy analysis: For pure Delonix regia seed polymer (Fig. 2), the band at 3430.09 cm−1 represents O–H stretching vibration. The band at 2924.52 cm−1 is due to C–H stretching of the $–CH_2$ group The bands due to ring stretching of galactose and mannose appear at 1637.32 and 1657.13 cm−1. In addition, the bands in the region 1350– 1450 cm−1 are due to symmetrical deformations of CH_2 and C-OH groups. The bands due to primary alcoholic $–CH_2OH$ stretching mode and $-CH_2$ twisting vibrations appear at 1050 to 1021 cm−1. The weak bands around 770 cm−1 are due to ring stretching and ring deformation of α-D-(1-4) and α-D-(1-6) linkages.

Differential Scanning Calorimetry (DSC): Differential scanning calorimetry (DSC) was used to measure the occurrence of exothermal or endothermal changes with increase in temperature. DSC, because of its sensitivity and accuracy, has been extensively used to study the phase transitions of polymers. The DSC curve of Delonix regia polymer exhibited endothermic peak at 87.37°C. (Fig 3).

X-Ray Diffraction Studies (XRD*):* The X-ray diffractogram of DRSP are shown in (Fig.4). The Bragg reflection angle, 2θ, along with the interplanar spacing d, and the relative intensity of the peaks were calculated. The interplanar spacing has been calculated using Bragg's equation given as; $n\lambda = 2d \sin\theta$, where θ is one half the angle read from the diffractogram**.** XRD pattern of the polymer has shown peaks with low intensity which confirms the amorphous nature of the polymer.

Scanning Electron Microscopy (SEM): The biological and botanical source of a pharmaceutical material serves as a determining factor in the granule shape, size and morphology. As a result, these characteristics not only help to differentiate between various materials but also give an indication of the processing parameters. The SEM of DRSP are shown in Fig.5 It exhibits fairly regular, tiny granules and slightly elongated with rugged appearance. These properties could be of importance when considering applications based on surface characteristics, for example, use of granules as carrier particles. SEM photographs of powdered polymer, taken at different magnification, shows gum like mass which is devoid of crystalline structure.

Particle size distribution: Determination of particle size is very important as it influences the hydration and viscosity of the DRSP. The major determinant of hydration kinetics is the particle size, which reflects the changes in surface area exposed to water. There is an inverse relationship between the dissolution rate and particle size. In view of this, DRSP was characterized on the basis of particle size. The particles sizes distribution was found to be 71.992 μm at d(0.1) as shown in Fig: 6

CONCLUSION

The information obtained from preliminary phytochemical screening will be useful in finding out the genuinity of the drug. Hence it was thought worth to investigate pharmacognostic profile of the isolated gum will assist in standardization for quality, purity and sample identification.This natural polymer also, similar to guar gum, Locust bean gum, and xanthum gum contains galactomannons as one of the active constituents. These gums are used in formulation of sustained release drugs, tablet preparation, microencapsulation and preparation for treatment of ulcers and diarrhoea. The natural polymer showed excellent swelling property in water, so it can be used as a matrix forming polymer and as release retardant in sustained drug delivery system. The low moisture content present in this natural polymer suggests its suitability in formulating even with moisture sensitive drugs. Therefore plant products serve as an alternative to synthetic products because of local accessibility, eco-friendly nature and lower prices compared to imported synthetic products.

Table 1: Technological characterization of microbial load of DRSP

Natural gum No.	CFU/mL	Microbial load (No. of CFU/g of gum)
DRSP	11	100

Table: 2 Extractive value and ash analysis of Delonix regia seed polymer

Parameters	Result
Extractive Value	
Water	22.25 ±1.51%
Ethanol	13.56 ±0.46%
Chlololform	4.73 ±1.64%
Ash value	
Total ash value	4.9 ±0.07%
Acid insoluble ash	3.2 ±0.11%
Water soluble ash	1.5 ±0.06%
Sulfated ash	Nil

Table 3: Preliminary photochemical screening of Delonix regia seed polymer

Phytochemical group	Distilled Water	CH_3OH	$CHCl_3$
Carbohydrate	+	+	+
Protein	-	-	-
Alkaloid	-	-	-
Steroids	-	-	-
Flavanoid	-	+	+
Terpenoids	-	-	-
Glycoside	-	-	-
Saponin	+	+	+
Tannin	-	-	-
Fixed oil	-	+	-

+ = positive, - = Negative, CH_3OH =Methanol , $CHCl_3$ = Chlololform

Table 4: Colour Analysis of Delonix regia Seed polymer (DRSP)

Treatment	Distilled Water	Methanol	Chloroform
Hcl	Light Yellow	Light Yellow	Light Yellow
H_2SO_4	Light brown	Light Yellow	Light Yellow
HNO_3	Light Yellow	Fenugreek Yellow	Reddish brown
Acetic Acid	Light Yellow	Light Yellow	Light Yellow
Ferric Chloride	Yellowish green	Yellowish green	Yellowish green
10% NaOH	Light Yellow	Brownish red	Reddish brown

Table 5: Physico-Chemical properties of Delonix regia seed polymer

Parameters	Result
Acid Value (Mg of KOH)	2.349
Relative Solubility (gm/ml)	
Water	0.844 ±0.034
Ethanol	0.771 ±0.012
Chloroform	0.60±0.018
P^H Buffer	
1.2	$5.18 \pm 0.8 \times 10^{-3}$
4.0	$8.4 \pm 1.0 \times 10^{-3}$
6.9	$10.8 \pm 1.5 \times 10^{-3}$
8.0	$12.6 \pm 1.7 \times 10^{-3}$
Viscosity (cps)	128.99 ±1.18
Swelling index (%)	140.38 ±2.5
Water retention capacity (ml)	3.8± 0.40
Hydration capacity	1.5± 0.03
Moisture sorption capacity	1.57± 0.52
Angle of repose (^{o})	37.6
Bulk density (gm/ml)	0.486
Tapped density (gm/ml)	0.552
Hausner ratio	1.3
Carrs index (%)	23.22
Loss on drying (%)	5.4

Fig: 1A Endosperm of Delonix Regia Seed Polymer (DRSP)

Fig: 1B Endosperm of Delonix Regia Seed Polymer Powder(DRSP)

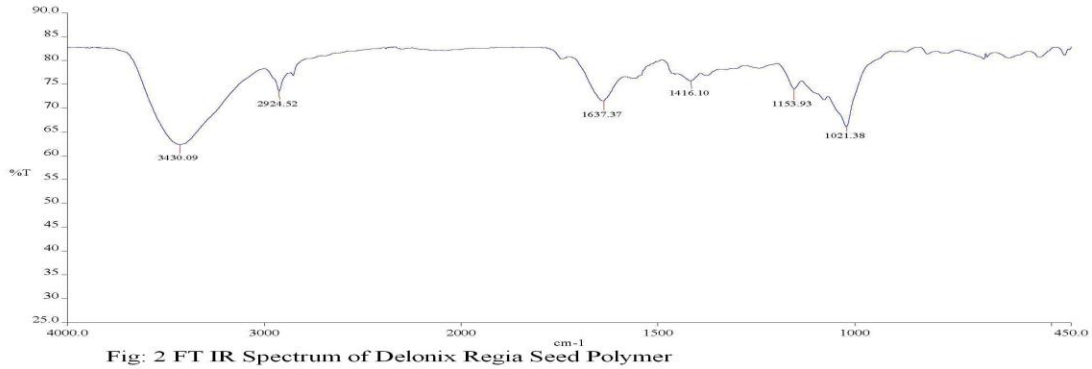

Fig: 2 FT IR Spectrum of Delonix Regia Seed Polymer

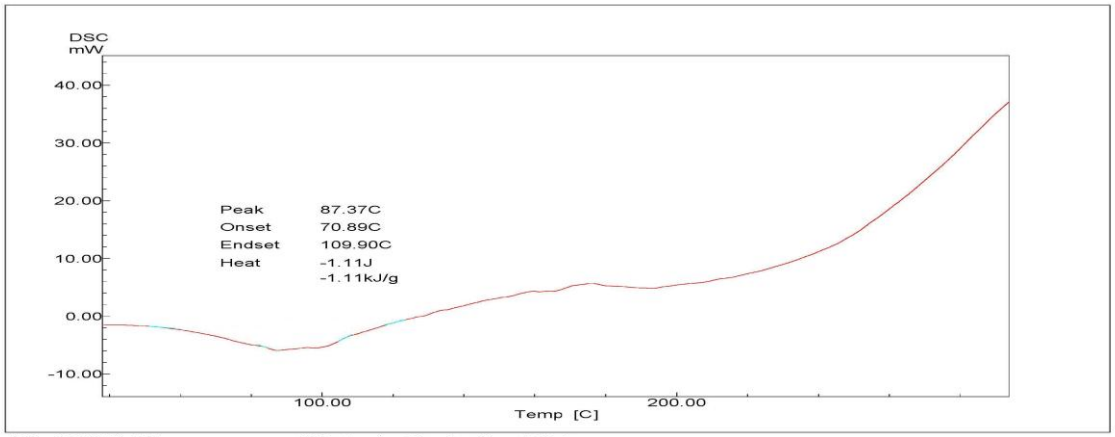

Fig:3DSC Thermogram of Delonix Regia Seed Polymer

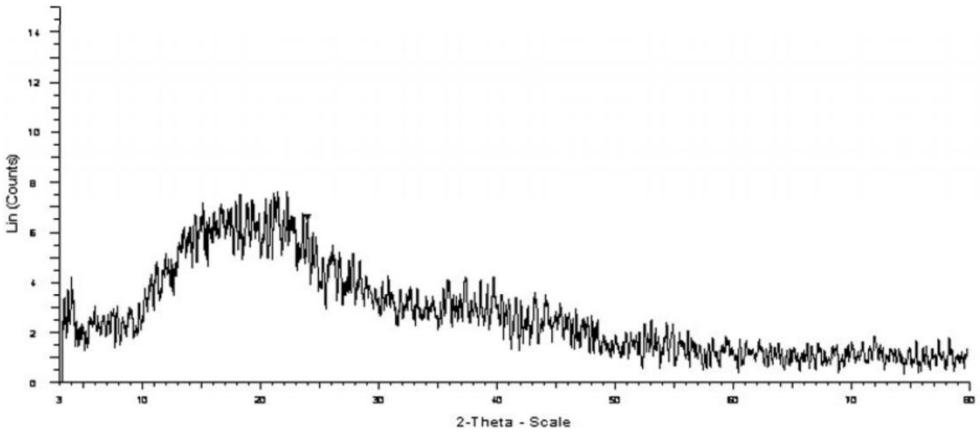

Figure 4: XRD pattern of Delonix regia Seed polymer

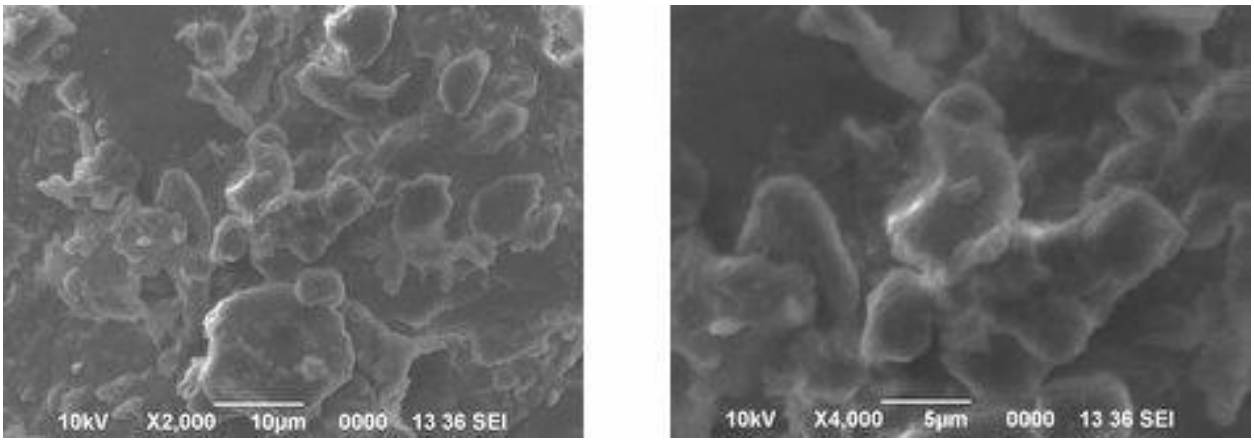

Figure 5: SEM Photographs of Delonix regia seed polymer at different magnifications

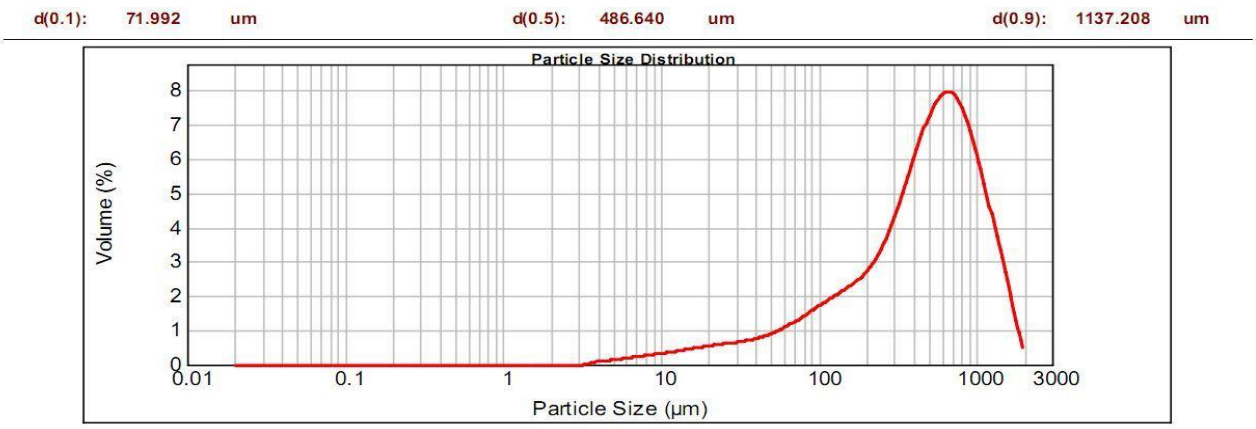

Fig : 6 Particle Size Distribution of Delonix Regia Seed Polymer

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