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A Review on Bio-resins

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Abstract

Bio-resins increases mechanical and structural properties of laminates and also used in systems where structural strength is important. It is made from several sources such as vegetable oils or blends, cashewnut shells, soybean, cotton seed, sugarcane and is cost effective and cause less pollution as it is not synthesized petro-chemically. Resin extraction is the main step in developing a bio-resin as this increases yield of the bio-resin. The solvents used for plant extract are ethanol, methanol, acetone, water chloroform, sulphuric acid, and Dimethyl Sulfoxide (DMSO). Adhesiveness of the bio-resin is increased by utilizing complex polymerization and crosslinking reactions. Graft co-polymerization processes are also used to increase adhesiveness. The key component for a bio-resin development is starch, lignin, flavonoids, that are fibrous in nature. This review studies gives an overview of sources, preparation and the different characterization tests required for a bio-resin.

Keywords
Adhesive, bio-resin, composite, environment, resin

Introduction

Bio-resins have risen as another alternative to conventional polyurethane-based plastics as they can be solidified to get biodegradable plastics too. Moreover, using bio-resins decreases the harmful emissions that occur while using and developing synthetic resins and utilizes plastic waste if composite laminates are made using plastic sheets and bio-resin [1]. Vegetable oils have been broadly utilized for the generation of bio-resin, they can be developed on a large scale or small scale or on Nanoscale. Blends of vegetable oils (soybean oil, corn oil, linseed oil, isomerized/conjugated oils, and so on.) with styrene and divinylbenzene have been fundamentally or catatonically polymerized within the sight of different fillers and filaments, for example, natural muds, glass, hemp, flax, jute or kenaf strands, wood flour, sugarcane bagasse, spent germ, corn Stover, wheat straw and recovered cellulose. Greener polymerization strategies, for example, olefin metathesis polymerization have additionally been connected to bio composite creation. Fleece, silk, human hair and plumes and so on can be used as fibers which are naturally available. Fleece has a few qualities that recognize it from hair or hide; it is pleated, it is flexible, and it develops in staples. Fiber taken from creatures or furry warm-blooded animals e.g., sheep fleece, goat hair (cashmere, mohair), alpaca hair, horsehair and so forth. Fleece is the material fiber. There are two types of bio resin: degradable and compostable.

Degradable bio resins can continually be broken down into smaller and smaller pieces—they are different from biodegradable resins, because they cannot be reduced to simple biological matter. Compostable resins can be used as mulch after being mixed with specific bio products at a composting plant [2]. Recent reports estimate that the demand for biodegradable and compostable plastics will increase by 20 percent per year—this would equal 420 million lbs of biodegradable or compostable plastic per year in 2010.

Several companies have been generating new **biodegradable and compostable plastic** families, which may serve as smart alternatives to traditional plastic. One such family, Mirel, depends on corn sugar as its main base, and its resin is used to create plastics with ranging levels of flexibilities. Mirel resin-based plastics can be rigid or soft, are heat and hot liquid resistant, and can be used in place of olefin in many applications [3].

A sustainable polypropylene, Biopropylene, has been developed by Cereplast Inc., who looks to replace a minimum of 50 percent of the petroleum-based plastics with renewable-resource based material. Currently, the company is working with Cosmolab to supply them with bioresins to create jars and enclosures for cosmetic packaging. Additionally, Enterprises Ltd. Plans to use Cereplast's compostable resins for a line of

restaurant and nightclub items [4].

Most of the companies are not going green nor produce new, bio-conscious resins. They continue to use petroleum-based resin, increase in prices, are limiting the quantity of petroleum they use. To achieve this, many companies use a mix of new and recycled material in products [5].

2. Study of Bio-resins

Bio-resins can help increase mechanical and structural properties of laminates and be used in systems where structural strength is crucial. Bio-resin can be made from vegetable oils and moreover there is a possibility of making bio-resin from cellulose. Natural fiber is available which can be used to make bio-composites [6]. Extensive research is being carried out in this field. From the extensive literature survey, we can also see the advantages bio-resins have over synthetic resin. They are more cost effective and less polluting in terms of emissions given out during use and during production. Bio-resin extraction is the main step in developing a bio-resin. Adhesiveness of the bio-resin must be increased by utilizing complex polymerization and crosslinking reactions. A Dotan(2014)[1] suggested that natural resins lack adhesiveness and must be modified and used with synthetic resins to reduce its harmful effects.Table 2.1 gives an overview of Bio-resin

Table 2.1 Literature on need and an overview of Bio-resin

Author name(year)	Suggestion / Remark
A Kovats(2011)(1)	Natural resins lack adhesiveness and must be modified or synthetic resins must be used but synthetic reins give out harmful gases during it's production phase and while using it.
	Bio-resins are an alternative to synthetic resin and are more environmental friendly.
S Sengupta, D Ray (2017)(3)	Vegetable oils can be used to make bio-resins and the process used to make them.
Deewan Akram(2013)(4)	Fleece, jute, etc are natural fibers which can be used along with bio-resins made from vegetable oils.
A Gandini, TM Lacerda (1992) (5)	Description on how to make bio-composites is given.

2.1 Composition of bio-resin

The key component for a bio-resin development are starch, lignin, flavonoids, that are fibrous in nature. From literature patents and journals, we can explain the important composition of a bio-resin as shown in Table 3.3. From the above literature survey, there is a possibility of synthesizing a bio-resin using organic waste. As many of these papers say, that synthesis of bio-resin was carried out using soybean, cotton seed, sugarcane and so on and all of them had starch in it. So, it was concluded that organic waste can be used to develop a bio resin as it contains starch. Moreover, the bio resin was derived from starch after converting it to glucose.

2.2Preparation of Bio-resin

Synthesis of bio-resin is from powdered source extracted by various solvents and the methods used are shown in Table 3.4. There are many ways to develop a bio-resin. The most common sources being vegetable oils and starch. Graft co-polymerization processes are used to increase adhesiveness. Cellulose can be converted to glucose. It can also be converted to HMF directly. HMF (Hydro Methoxy Furfural) Resin is the resin to be derived from glucose. The most successful medium for this conversion is DMSO (Dimethyl Sulfoxide). The reaction which gives HMF from cellulose is a dehydration reaction that takes away four water molecules from glucose.

2.3 Solvents for extraction of Bio-resin

The organic sample obtained contains the solvation medium and the bio resin. Therefore, extraction of the bio resin from the solution is necessary. Hence literature survey for the same was conducted. And the observations are recorded in Table 3.5. For plant extract, the most appropriate solvents used are

ethanol, methanol, acetone, water chloroform, sulphuric acid and Dimethyl Sulfoxide(DMSO). Therefore, these solvents will be used for bio- resin extraction. Cunshan Zhou and Shulan Liu have also stated that the solvent used also enhances extraction process with respect to time and temperature. Hence optimization studies will be carried out.

All the above papers say that epoxidation is an important step that must be carried out to produce a resin Cellulose can be converted to glucose. It can also be converted to HMF directly. HMF (Hydro Methoxy Furfural) Resin is the resin to be derived from glucose. The most successful medium for this conversion is DMSO (Dimethyl Sulfoxide). The reaction which gives HMF from cellulose is a dehydration reaction that takes away four water molecules from glucose. To do this, the solid sample of organic powder must be dissolved in a medium such that the cellulose could be detected by FTIR.
Table 2.2 gives literature on bio resin source

Table 2.2: Literature on Bio-resin Source

Sl No.	Author name(year)	Ref No.	Suggestion / Remark
1	Akaranta & Wankasi(1999)	[6]	Formaldehyde extracted from peanut skin tannin with resorcinol and cashew nutshell fluid makes a bio-resin synthesized with a synthetic resin and adhesiveness of the new engineered resin is increased.
2	Akesson et al(2006)	[7]	Acrylate epoxidized soybean oil (AESO) with flax fiber mass was promising as a resins and can be used as wood adhesives.
3	Nacu Hern´andez(2010)	[8]	Latex have a mind boggling creation, incorporates alkaloids, terpenoid mixes, starch
5	Nathan(2013)	[9]	Synthesis of hemp oil based bio-resins
6	Gerald et al(2013)	[10]	Resins blended from soybean-oil-based polymers are competitive in properties with those of petrochemical based resins.
8	Zhao et al (2015)	[11]	Wattle tannin is very similar to phenol in terms of poly-hydroxylphenol structure and chemical properties and sucrose on heating gives 5- HMF. Therefore, sucrose and tannin can be used as adhesive components. Polysaccharides like starch and chitosan can be used as precursors to resin systems.
9	Suh and Matthew (2000)	[12]	Chitosan has good biocompatibility, fungistatic, bacteriostatic, bioactivity and bioresorbability properties.
10	Jeong et al (2009)	[13]	Sucrose under heat treatment gives 5- HMF adhesive.

11	Lee et al. (2011)	[14]	Sucrose under heating or acidic conditions gives 5-HMF adhesive.
12	Lihong Zhang, Yuyinh Zheng, Youfang Zhang and Tao Lin (2013)	[15]	Starch increases the tack of phenolic resins. Starch can be used as a substitute for formaldehyde in phenol formaldehyde resins and since it is abundantly available at a low cost and is environmentally a better option, this option is preferred. Glucose and furan derivatives can be obtained from starch and it is known that pentosans in starch can be hydrolyzed into monosaccharides which is dehydrated to give furfural. Increasing crosslinking rate and degree is seen with increasing the content of lignin in phenol based resin.

Table 2.3: Composition of Bio-resin

Sl No.	Author name/ Patent No. (year)	Ref No.	Suggestion / Remark
1	USA Patent Application-0295196 A1 (2012) (	)[16]	Starch that was separated from corn is utilized and its adhesiveness increased with the assistance of polybutyrate.
2	USA Patent Application-8476329B2 17(2013)(17)	[17]	A bio-resin is utilized by incorporating a polyurethane and a bio polyol and is significantly free of aprotic solvents that synthetically decay in the presence of water. The primary bio polyol incorporates a characteristic oil part. A second bio polyol incorporates the result of the reaction of a characteristic starch and an allylene oxide.
3	Nur Syazana Bt Md nazri(2014)	[18]	An essential commercial resin is alkyd resins. They are derived from a mixture of polycarboxylic, polyols and unsaturated fats that originate from vegetable oils.
4	Stemmelen M. (2015)	[19]	Bio-resin from epoxidized vegetable oil
5	Koch and Pein (1985)	[20]	Phenol and 5- HMF adhesive was researched.

Table 2.4: Preparation of Bio-resin

Sl No.	Author name/ Patent No. (year)	Ref No.	Suggestion / Remark
1	Marcos(1995)	[21]	Synthetic bio-resins with tannin Liquified in Phenol

			were reacted. The tannin powder was slowly added to the reaction vessel, and the temperature was raised to 137°C ± 2°C.The reaction was carried out for several time periods: 30, 60, 90,120, and 180 min.
2	Gandini (2006)	[22]	Synthesis of polymers from renewable materials.
4	Dinda et al (2008)	[23]	Epoxidation kinetics of cottonseed oil using a hydrogen peroxide catalysed by liquid inorganic acids was studied.
5	Chimar technology	[24]	Urea-Formaldehyde resins produced. Soy protein was in the form of flour or isolated soy protein (SPI)
6	Paul et al(2013)	[25]	The collected resin was stored in the freezer at −18◦C for further use. The fibres were washed several times to remove the pith, air dried and then stored in plastic bags for further use.
7	Andreia A. Rosatella, et al(2011)	[26]	Cellulose could be directly converted to HMF. Up to 55% of HMF could be obtained.
8	Fang Liu, Siva Sivoth thaman and Zhong chao Tan (2014)	[27]	20 wt% of NaCl and mixed solvents (DCM and 2-Butanol) performed better than respective single solvents in the extraction of 5-HMF.
9	Cheng- Han Hsieh, Hung- Jie Liou (2017)	[28]	Properties of HMF Resin can be enhanced by adding epoxy, formaldehyde, or phenol resins.
10	Heller (1986)	[29]	Boron-oxygen compounds could be useful in enhancing adhesiveness
11	US Patent Application 5025051A(1987)	[30]	Perchloric acid would be useful in enhancing heat and light resistance
12	Nie et al.(2013)	[31]	Starch-g-poly-vinyl acetate (Starch-g-PVAc) and epoxy were used as modifying agents to be added to corn starch. Poly vinyl acetate additive played the role of increasing dry shear strength of the starch adhesive. Epoxy additive played the role of crosslinking agent and a water resistant component to improve wet shear strength of the starch resin. 30:47:23 was the

			optimal starch: starch-g-PVAc: epoxy ratio used which resulted in the highest bond strength.
14	Meimoun (2017)	[32]	Graft copolymerization of starch is carried out so that adhesiveness of starch would enhance.
15	H Koch, et al. (1985)	[33]	Starches were incorporated into novolak and resol type phenolic resins via acid catalyzed reactions in the presence of formaldehyde and phenol.

Table 3.5: Solvents for Extraction

Sl No.	Author name(year)	Ref No.	Suggestion / Remark
1	Chen HG, Yu YG, Zeng OX (2002)	[34]	The plant powder sample was separated consistently with three distinctive oceanic solvents with distinctive extremity that being polar protic dissolvable solvents (methanol, ethanol), polar aprotic dissolvable solvent (acetone) and non-polar solvent (chloroform). The arrangement was then whirled for 1 hour at room temperature utilizing an orbital shaker.
2	PérezJiménez, S. Arranz, M. Tabernero, et al (2007).	[35]	Aromatic extracts were obtained by utilizing water and distinctive concentrations of fluids like methanol, ethanol, and acetone.

IV. Conclusion

The advantage of this review is that the conclusion arrived at is that glucose which is the basic building block of most organic material can be converted into a resin. Many other substances like vegetable oils, saps, etc can also be converted into a bio-resin. The characterization tests required for a bio-resin is very similar to those of synthetic resins. Limitations of bio-resins is that the adhesiveness is limited which is a major contributor to strength of final product and the output quantity of bio-resin is very little compared to input quantity and impurities may exist which is why extraction procedure is crucial. The application of the manuscript is to set the foundation for research on glucose based adhesives, so that agricultural and organic waste can be utilized to make the same. This will also help decrease the amount of waste and help in its conversion to value.

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