

Use of Renewable Resources for Polymer Synthesis

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Abstract: The discovery of novel materials with specific properties will always complement the advances in technology. The concept of polymerization for the synthesis of organic and inorganic polymers has evolved a new scope for synthetic products, but the most serious objection by environmentalists against such polymers is their non-biodegradability. Hence, the “bio-degradable polymers” advertised for the use of renewable resources for polymer synthesis to bring forward the concept of environmentally benign chemistry. The natural oils conceptualized their major role not only in the fluid hydro-dynamics but also in polymer synthesis that can be new tailor made class of biodegradable polymers.

Keywords: Renewable resources, Natural oils, Polymerization, Tailor made biodegradable polymers.

I. INTRODUCTION

All modern polymers have their origin in petroleum, it has been argued that this reliance on polymers constitutes an unnecessary drain of energy resources. Thus the use of renewable resources for polymer synthesis and energy production is gaining increased importance. Several reviews appeared in recent years on the use of renewable resources for polymer synthesis [1]. These renewable resources which are also classified as natural polymers obtained from natural resources such as plants and animals. Examples: cellulose, starch, rosin oil, castor oil, guar gum, cotton, silk, wool, glycogen (all plant derived) and few animal oils viz. whale oil, lard oil, tallow oil, sperm oil for mechanical utility in lubrication. The objective of present paper is to highlight the use of plant based natural resources for use in polymer synthesis.

II. PLANT BASED NATURAL RESOURCES FOR POLYMER SYNTHESIS

Cellulose($C_6H_{10}O_5$)_n: One of the abundantly occurring renewable resources of wide applicability is cellulose which is a natural polymer continuously renewed by photosynthesis [2]. The reactivity of the hydroxyl group of cellulose molecules in heterogeneous reactions and the polymeric research involved in synthesizing new products for special applications [3]. Seneker et al [4] presented a review on improvement of the biodegradability of highly substituted derivatives of cellulose that are used commonly as thermoplastics. These were hydrophobic because most of the 3OH groups of the repeating glucopyranosyl units of cellulose are replaced. Water solubility is a contributor to biodegradation, but hydrophilicity retards the rate of processing of thermoplastics. To achieve biodegradation, but hydrophilicity retards the rate of processing of thermoplastics. To achieve biodegradation, the C-2 OH groups on continuous repeating rings of glucopyranose must remain un-substituted, preferably in 5 – or 6 – segments runs of C- 2 unsubstitution. Reaction parameters that control substituent placement and the costs of producing viable products were discussed. Improvement of the solubility of cellulose can be achieved by partial or complete substitution of H of the hydroxyl groups resulting in cellulose ethers [5].

Bojanic et al [3] reviewed new synthetic possibilities of introducing functional groups onto the cellulose molecule with the goal of obtaining cellulose esters, ethers and their derivatives, as well as covalently bound biologically active molecules to cellulose and graft cellulose copolymers. Its use in the synthesis of fibre and film production from conventional and new processes and its esters for extrusion and moulding and also the ways to realize the demanding

property of biodegradability has been reviewed by Simon et al [6]. The use of polysaccharides both in the context of film forming polymer electrolytes and of surface chemical modification of cellulose fibres and the synthesis of polyesters and polyurethanes based on lignins of various origin and a large section devoted to furan polymers and oligomers possessing special properties and to the application of Diels – Alder reaction to modify reversibly the architecture of macro molecules bearing furan rings and the use of vegetable oils as diluent in printing formulations has been discussed in detailed by Gandini and Belgacem [7].

Rosin Oil ($C_{20}H_{30}O_2$) : The use of Rosin, a renewable resource from plant origin in the synthesis of poly amide – poly imides is well documented. Poly amides and polyesters prepared by polymerization of acrylic acid or rosin maleic – anhydride rosin adduct (RMA) with aromatic diamines and diols were more thermally stable than those prepared from aliphatic diamines [8]. A new class of poly(esterimide)s synthesized by Diels-Alder reaction of maleic anhydride and rosin (L- pimaric acid components present in gum rosin being active species) were reviewed by Maiti et al [9]. The polymers were amorphous, soluble in highly polar solvents are reasonably thermo stable.

Cardanol ($C_{21}H_{30}O$): Cardanol, is another renewable resource and waste of the cashew industry, which has been used for synthesis of a novel thermoplastic poly urethane [10]. Synthesis of thermo setting resins derived from cardanyl – acrylate with formaldehyde and substituted aromatic compounds was reviewed by Nayak et al [11], and as selective ion ex-changer for certain metal ions by Sahoo et al [12]. The use of cardanol in the preparation of flame retardant polymers [13], resins by condensing cardanyl acrylate with furfural [14] and semi-interpenetrating polymer networks based on cardanol-formaldehyde-substituted aromatic compounds copolymerized resins and castor oil polyurethanes have been reviewed [15].

Castor Oil ($C_{57}H_{104}O_9$): Castor oil has been taken as the precursor for the synthesis of high performance polymers. Castor oil, has long been used in paints, varnishes, lacquers, sulphonated oils and other coating formulations [16]. Sperling and his co workers [17 – 20] has reported a series of interpenetrating networks from castor oil based polymethane derived from toluene-2,4-diisocyanate and vinyl-monomer (styrene). Additional studies were carried out by Tan [21,22] on IPNs derived from castor oil polyurethane and a homo-polymer or copolymer of styrene, methylmethacrylate and acrylonitrile. Ramesh et al [23] reviewed the castor oil based polyurethane anionomers. Knaub and Camberlin [24] reported new reactive system based on castor oil, aliphatic diiso cyanates and aromatic diamines. Such systems would be interesting for CAST or RIM (reaction injection moulding) and RRIM (reinforced RIM) processes [25 – 27].

The biodegradable polymers are those that can be decomposed by bacteria/microorganism within a suitable period of time so that biodegradable polymers and their degraded products do not cause any serious effect on the environment. The decomposition reaction involves hydrolysis (either enzymatically induced or by non-enzymatic mechanism) to non-toxic small molecules which can be metabolised by or excreted from the body.

The common examples of aliphatic biodegradable polymers include poly-glycolic acid (PGA), poly-hydroxybutyrate (PHB), poly-hydroxybutyrate – co – beta hydroxyl valerate (PHBV), poly- caprolactone (pcl), Nylon – 2 and Nylon – 6 and many more [28].

III. CONCLUSION

The basic object of utilizing renewable resource for polymer synthesis is the need to transform traditional non degradable plastic waste to a tailor made inherently bio degradable polymer by incorporation of a natural moiety with a synthetic one.

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