INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Hydrogels are the most versatile multifaceted polymer material which is widely applied in biomedical devices, bioelectronics, drug delivery, water remediation, and recently as fire retardants. The demand for low carbon footprint encourages the world to develop environmentally friendly and sustainable hydrogels. To achieve sustainability, the idea of valorizing waste biomass to formulate biomass-based hydrogel has become the primary focus of many researches. In this thesis, we have tried to valorize extracted components of Arundo donax namely, cellulose and lignin to formulate biomass-based hydrogels. The lignin extracted was irregular shaped and difficult to disperse in water. This particular problem was resolved by reducing the size of the lignin particles. Two different methods were opted to synthesize nano sized lignin particles. In the first method, lignin was ultrasonicated to produce nano sized lignin (10 to 50 nm). In the second method acetone–water cosolvent method (coprecipitation) was opted to produce core and shell structured spherical lignin particles (50–200 nm). These lignin particles were doped in PVA–Chitosan (CS) and PVA–xanthan gum (XG) blends respectively to formulate biopolymer based hydrogels. These lignin particles act as reinforcements and substantially improved the elastic moduli (G') of the formulated hydrogels. Ultrasonicated lignin was further utilized to disperse multiwalled carbon nanotubes (MWCNT) in water and incorporated in PVA–CS blend to developed physically crosslinked conducting hydrogel. The conductivity of the formulated hydrogel was determined by electrochemical impedance spectroscopy (EIS) measurement. The conductivity of the formulated hydrogel was estimated at around 8.22 mS cm-1 for 1% MWCNT incorporation. The spherical lignin obtained as a result of the coprecipitation method was doped in basified PVA–XG and crosslinked by Na2B4O7. This hydrogels was regenerated on cotton fabric to obtain PVA–XG–LNP hydrogel coating which substantially reduced the flammability of cotton cloth. Cellulose, another component extracted from biomass is extremely susceptible to fire. To improve its fire retardancy cellulose hydrogel was formulated by dissolving cellulose in NaOH/Urea mixture and crosslinking it with methylene bisacrylamide (MBA). To further improve the fire retardancy kaolin was added to the hydrogel matrix. The cellulose hydrogels were regenerated on cotton fabric to impart fire

retardancy to cotton fabric. The efficacy of fire retardancy was validated by performing a cone calorimetry test (CCT), vertical flammability test (VFT), open fire test (OFT), and measuring the limiting oxygen index (LOI). Further, the swelling and water retention ability of the fire retardant hydrogels were measured to check the water encapsulating and retaining potency. The network parameter of the hydrogels (mesh size, crosslinking density, and molecular weight between crosslinks) was also estimated using the results from the swelling test and elastic moduli (estimated by rheological studies). The results state that incorporation of 20% v/v LNPs in 2% w/v NaOH PVA–XG solution and 0.4% w/v Na2B4O7 crosslinker induced substantial crosslinking and hence increment in moduli and reduction in swelling ability and water retention ability was observed. Similarly, the incorporation of 2% w/v kaolin and a high amount of MBA followed similar findings. Performing thermal analysis of the hydrogels confirmed that the hydrogel formulated were highly thermally stable and high char producing (34.61 wt.% for PVA–XG–20% v/v LNPs hydrogel and 63 wt% for 2% w/v kaolin incorporated cellulose hydrogel). All these results postulate the successful synthesis of biomass extracted component based hydrogel and its application as conducting hydrogel and hydrogel fire retardants.