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Preparation and Characterization of Green Polymer from Industrial Waste

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Abstract – A novel hydrogel was prepared from industrial waste to form a green polymer with a higher swelling capacity. This hydrogel was synthesized by two methods, namely physical and chemical-crosslinking. In chemical-crosslinking, graft copolymerization between poly(vinyl alcohol) (PVA) and polyacrylamide (PAM) was carried out using ceric ammonium sulfate then mixed with the black liquor resulted from alkaline pulping rice straw in presence of *N*,*N*,-methylenebisacrylamide as crosslinker. In physical-crosslinking, the two polymers were mixed with the black liquor in the presence of the crosslinker without the initiator. The black liquor is an industrial waste results from the pulping method and consists of dissolved lignin and carbohydrates. The black liquor causes environmental water pollution due to throwing it into the sea. The formed hydrogels were characterized using FT-IR spectroscopy and scanning electron microscopy (SEM). Compared with the two hydrogels, it was noted that the chemical-crosslinker hydrogel had high swelling capacity compared to the physically-crosslinked one. The hydrogels formed were used also to study the influence of sodium chloride on the absorption capacity at room temperature and swelling ratios at different temperatures.

Hydrogels are polymeric networks, which absorb and retain large amounts of water. As the term 'network' implies, crosslinks have to be present to avoid dissolution of the hydrophilic polymer chains/segments into the aqueous phase [1]. Green polymeric material is a biodegradable material (neat polymer, blended product, or composite) obtained completely from renewable resources [2]. Because of their water-absorbing capacity, hydrogels are not only subject of investigation of researchers interested in fundamental aspects of swollen polymeric networks, but have also found widespread application in different technological areas, e.g. as materials for contact lenses and protein separation, matrices for cell-encapsulation and devices for the controlled release of drugs and proteins.

Agricultural residues represent an abundant, inexpensive, and readily available source of renewable lignocellulosic materials for paper, chemicals and other technical products [3]. The major constituents of biofibers (lignocellulose) are cellulose, hemicellulose and lignin [2]. Conventional technology for paper manufacture is based on digesting the raw material, (wood, recycled paper, and agricultural residues), which results in a black liquor. Black liquor is the liquor after it has been used in the digester and is "spent" and contains high caustic, lignin, silica and high total solids (TDS). Most of the paper industries which have black liquor concentration (in term of total dissolved solids) discard the liquor as it is or after some partial treatment to the river. Naturally, this leads to several water pollution problems. To be successful, the industry must find new ways to improve environmental and process performance.

The possibility of using the resulted black liquor in the synthesis of hydrogel is our aim in the present work. An investigation on the performance of the black liquor as physically and chemically-crosslinked hydrogel has been examined. Our observation showed a higher water absorption at 25 °C for the chemically-crosslinked hydrogel, 60.00%, compared to the physically one, 27.27%. Also, it was noticed that the absorption capacity depends on the temperature which shows less absorption at 50 °C, 27.72% for chemical-crosslink and 5.26% for physical-crosslink, compared to that at 25 °C. The nature of these hydrogels structures was characterized by scanning electron microscopy (SEM). The changes in morphology of hydrogel samples with different reaction are illustrated in Figure 1 for the fracture of both types of hydrogels, physically and chemically crosslinked. The EDX indicated the presence of a silica which can be found in the black liquor resulted from pulping the rice straw (Fig. 2).

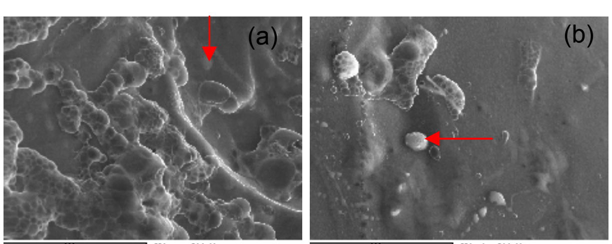

Figure 1: SEM image of a black liquor hydrogel, **a)** physically-crosslinlked and **b)** chemically-crosslinked. The arrow indicates the presence of silica.

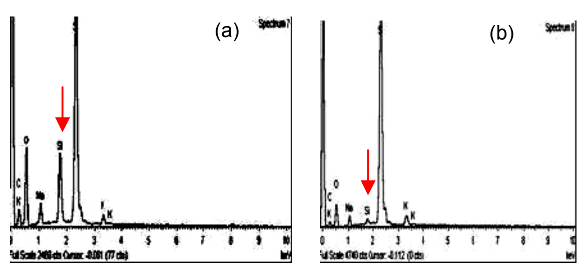

Figure 2: EDX image of a black liquor hydrogel, **a)** physically-crosslinlked and **b)** chemically-crosslinked, which represents the presence of the silica. The arrow indicates the silica

References

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