IMPACT PROPERTIES OF SISAL FIBER REINFORCED COMPOSITES: POLYURETHANE AND PHENOLIC MATRICES BASED ON SODIUM LIGNOSULFONATE

Fernando de Oliveira, Elaine C. Ramires and Elisabete Frollini

Macromolecular Materials and Lignocellulosic Fibers Group, Institute of Chemistry of São Carlos, University of São Paulo, Av. Trabalhador Sãocarlense, 400 São Carlos, Brazil
e-mail: elisabete@iqsc.usp.br

Key words: Sodium lignosulfonate, sisal fibers, phenolic resin, polyurethane

Summary. The aim of this study was to prepare composites from polymeric matrices derived from renewable sources and use sisal fibers as reinforcement. Sodium lignosulfonate was used as a substitute for phenol in the preparation of phenolic resin, as it contains aromatic rings of phenolic type, and as a substitute for polyols in the preparation of polyurethane, due to the presence of alcoholic hydroxyls which can react with the isocyanate group. The impact results showed that the presence of sodium lignosulfonate in the formulation of matrices provided good adhesion between the fiber and matrix of these composites, owing to strong interactions caused by the similarities of structures present in the fiber and the matrix. The results are promising and fulfill environmental expectations. Other tests are under consideration, such as flexural strength, thermal analysis and water absorption.

1 INTRODUCTION

Sodium lignosulfonate (NaLS) is obtained from renewable sources and was chosen as a substitute for phenol in the preparation of phenolic resins in view of its chemical structure, which features aromatic rings of the phenolic type. Also, the presence of alcoholic hydroxyls in the NaLS macromolecule enables it to be used as a partial substitute for the diols or polyols used in lignopolyurethane synthesis. Lignocellulosic fibers are compatible with both lignophenolic and lignopolyurethane matrices, owing to their structural similarities. The presence of polar hydroxyl groups in both matrices and in the main components of the lignocellulosic fibers (cellulose and lignin) favors the fiber/matrix adhesion. In this light, a very good interfacial adhesion is expected in these lignopolyurethane and lignophenolic composites (LPUC and LPC, respectively) reinforced with sisal fibers. Sisal fiber is considered a good reinforcement for polymer matrices, on account of its excellent mechanical properties. In addition, Brazil is the world's largest producer of this fiber.

2 EXPERIMENTAL

Phenol was completely replaced by NaLS (kindly supplied by Lignotech Brasil, São Paulo-SP, Brazil) in the synthesis of lignosulfonate-formaldehyde pre-polymer, carried out as described elsewhere [1]. LPC was produced by adding the sisal fibers (3 cm in length, 30 wt%, randomly distributed) to the pre-polymer. LPUC was made by adding diphenylmethane diisocyanate (MDI), NaLS and diethylene glycol (DEG) to the sisal fibers (25 wt%). In both cases, the fiber-resin mixture was stirred mechanically. Both composites were compression
molded under conditions established in previous studies [2]. The impact strength test was carried out as recommended in ASTM D 256.

3 RESULTS AND DISCUSSION

Figure 1 shows that the introduction of fibers reduced significantly the fragility of the lignophenolic thermoset (LPT), as can be seen in the impact strength of 1000 Jm⁻¹ achieved in this composite (LPC). The lignopolyurethane thermoset (LPUT) prepared with MDI, DEG and NaLS (unreinforced) showed an impact strength of 35 Jm⁻¹, while the reinforcement with sisal fibers (LPUC) increased this strength to 472 Jm⁻¹. After the impact test, the fiber bridging phenomenon was observed in most samples of both composites, which indicates good interfacial adhesion between fiber and matrix in the composite. In the LPC, the polar groups present in the lignosulfonate used in the matrix, combined with the aromatic structures typical of lignin, should favor the interactions of the matrix with polar groups and lignin present in the fiber. In LPUC, the hydroxyl groups of lignosulfonate, and probably those of the fiber, should have reacted with the isocyanate groups of MDI. These factors enhanced the adhesion at the interface, leading to an efficient transfer of load from the matrix to the fiber during the impact test.

4 CONCLUSION

The results showed that NaLS can be used to advantage in the preparation of phenolic and polyurethanes matrices, when they are reinforced with lignocellulosic fibers, since its presence increases the affinity between the matrices and fibers, leading to good mechanical properties. Another advantage is the high content of raw material obtained from renewable sources. This study is in progress and even better results are expected, mainly with respect to LPUC.

The authors gratefully acknowledge CNPq for the fellowship for F.O. and FAPESP for financial support.

REFERENCES
