Mechanical Properties of Natural Rubber-Polyethylene-rubber modified rice husk composites

*A. Ibrahim, A. Ishak and E.L. Chong
Polymer Research Center, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia.
e-mail: dia@ukm.my

Introduction

Rice husk (RH) powder as a filler for natural rubber (NR)/polyethylene (PE) or thermoplastic NR (TPNR) blends is inactive due to the hydrophilic nature of the cellulose (1). Filler-matrix interaction can be induced by surface modification of RH particles to minimize hydrophobic repulsion of TPNR surface. Pretreatment of the cellulose particles is necessary to expose the active sites for coupling reaction with any coupling agents. Liquid NR, a compatibiliser for NR and high density polyethylene (HDPE) (2), would be a potential agent to promote the filler-matrix surface interaction. In this study, rice husk was modified with LNR to improve adhesion especially in the rubber phase. NR was the major component in the thermoplastic natural rubber (TPNR) blends prepared and such incorporation of filler particles into the phase through preferential attraction would be more effective in changing the mechanical properties of the composites.

Experimemtal

RH powder, pretreated with 10% NaOH solution, was mixed with LNR solution and stirred with magnetic stirrer and immersed in a sonic bath for few hours. The RH obtained was dried, ground and sieved to the required size. Melt-mixing the filler with TPNR matrix was done at a predetermined condition in an internal mixer.

Results and Discussion

Scanning electron microscopy (SEM) examination showed that the untreated RH surface is smooth and NaOH washing had cleaned off the impurities, wax and natural fats, protecting the fibrous structure of the particle. The smooth and opaque rubber film on the RH surface after soaking in LNR solution emerged as a clear thin film on exposure to e-beam radiation. The fine layer of rubber was formed at the optimum exposure, 20 to 30kGy, of radiation (Fig.1). The film, however, degraded to patches of agglomerated particles on further exposure to radiation. The e-beam initiated the formation of radicals leading to chain scissions and cross-linking networks within the polymer (3). Chemical reactions of the radicals with the exposed surface groups caused the polymeric coating to be adsorbed into the cellulose surface. However at 50kGray of radiation, degradation of the polymer becomes dominant and caused the rubber coating to degrade forming agglomerate of particles.

The rubber coated RH did not exhibit any observable peaks associated with cellulose rubber interaction but significant peaks are observed on exposure of the coated RH to e-beam radiation. The intensity of –C—H vibrations at 2958cm^{-1}, 2929cm^{-1} and 2857cm^{-1} had decreased on exposing the rubber coated RH to e-beam (22). The peaks at about 1454cm^{-1} and 1373cm^{-1} were assigned to the ester groups while the 1630cm^{-1} peak to hydrogen bonded carbonyl group or enol (4). The rise of the later peak which seems to be at the expanse of the former on exposure to radiation is rationalized as due to the ester and ether groups degenerated to carbonyl groups which forms hydrogen bonding with the neighboring groups. The 834cm^{-1} peak arising from the out of plane bending vibration

of =C—H group decreased after subjecting the sample to 20kGy radiation. Chains degradation caused these active vinyl groups to form free radicals on exposure to radiation and subsequently initiated cross-linking networks within the rubber phase and, to a limited extent, at the rubber-filler inter-phase (5).

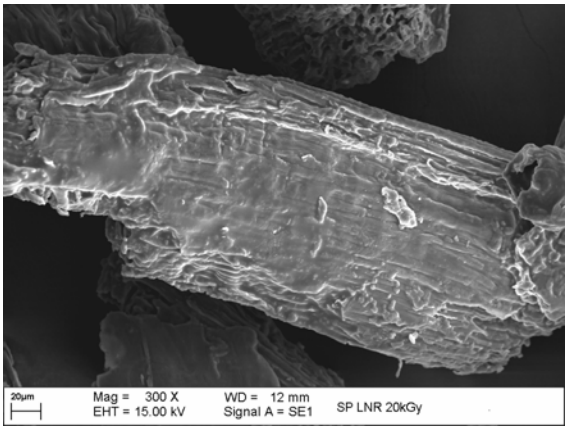

Fig. 1: SEM of rubber coated RH surface.

Incorporation of the rubber coated RH as filler into the TPNR matrix produced composites with tensile properties varying on the radiation dosage. The stress and modulus of 10% filled TPNR composites, as shown in the Fig. 2, increase on radiation and maximized at about 20 to 30 kGy exposure. However the modulus seems to maximize at about 30kGy of radiation.

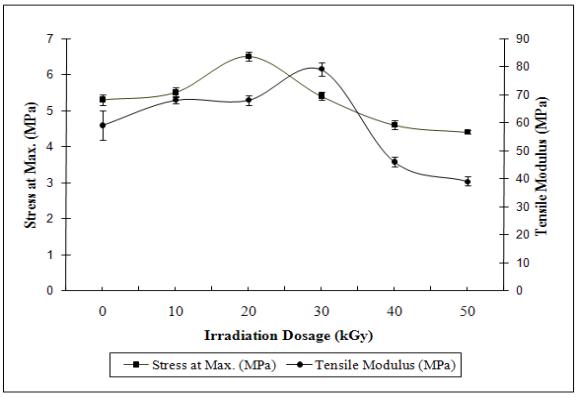

Fig.2: Variation of stress and modulus with radiation dosage.

A similar trend was shown by the impact strength with radiation dosage and maximized at about 20kGy radiation. The increment in tensile properties was due to the increasing interaction between the filler and matrix facilitating a more efficient energy transfer process

Irradiation caused curing of rubber and bonding of the film to RH surface. Particle to matrix interaction will be improved as particle-particle interaction is reduced. Hence a more homogeneous distribution of filler particles will be possible and better energy transfer mechanism created. The tensile modulus optimizes at a slightly higher dosage due to the stiffening of the filler particles when the rubber coat is slightly over-cured. The cross-link net-working is stronger with greater intensity of cross-linking density. Over-curing at higher dosage leads to degradation of the rubber coating, agglomeration and hence weakening of the particle coating.

Acknowledgement

The financial support from Ministry of Science, Technology and Innovation (MOSTI) Malaysia through research grant 06-01-02-SF0411 and Universiti Kebangsaan Malaysia.

References.

1. Colom, X., Carrasco, F., Pages, P. & Canavate, J.; Composites. Sci. Technol. 2003, 63, 161.
2. Suzeeren, M.J., Ishak, A. & Ibrahim, A.; J. Polymer Res. 2006, 13(4), 315.
3. Turner, D.T.; Polymer, 1960, 1(1), 27.
4. Pavia, D.L., Lampman, G.M. & Kriz, G.S.; Introduction to Spectroscopy: a guide for student of organic chemistry, 3rd Edition, Thomson.
5. Ratnam C.T., Nasir M.B. & Khairulzaman M.D.; App. Polymer Sci., 2001, 81, 1914