PERFORMANCE EVALUATION FOR PVC COMPOSITE SYSTEMS

I-PVC-FIBER GLASS COMPOSITES

A.I.ALI*, Y. M.S. El-SHAZLY**, R.R. ZAHRAN**, and B.A. GEBRIL**
*Egyptian Petrochemicals Company, Alexandria-Egypt
**Department of Chemical Engineering, Alexandria University, Alexandria 21544-Egypt

Introduction

In this study, composites were prepared from a combination of different formulations of PVC that are produced by the Egyptian Petrochemicals Company and different forms of the glass fiber reinforcement (Roving Cloth RC, Glass Tape GT, and Glass Mat GM). The physical and mechanical properties were evaluated as a function of the fraction of fiber present, the existence of coupling agent at the interface and the weathering period. It is found that the fiber content fraction and its form has a great effect on the composite properties. Moreover, the presence of the coupling agent plays a role as it enhance the bonding and the stress transfer between the matrix and the fibers [1]. The results of the different tests are presented.

Experimental

Materials

Four different formulations of PVC: shoe and cable (PPVC) and pipe and profile (UPVC) are used as the matrix phase. Three different forms of glass fiber were used:

- RC: an E-glass roving cloth (plain weave) RC-500 supplied by Vetrotex (USA),
- GT: an E-glass glass tape (plain weave) RS-150, and
- GM: a glass mat M5-300.

Vinyl tri-methoxy silane VS 604 (Union Carbide Corporation) was used as coupling agent. It was added on the basis of 1 part: 5 parts of fiber. All materials were used as received from the manufacturers.

The composite preparation was performed in the following sequence: first, the PVC dry blend (powder) were calendered into a 0.5mm thick sheet using an oil-heated brabender equipped with two roll mills, model PM-3000. The sheets are then cooled, weighed and stacked with the glass fiber.

Then they are compression molded into a 3 mm thick composite plate by means of a Presa 120TM Fabesint Hydraulic Press.

Physical properties were tested; density, Vicat Softening Point and electrical resistivity. Tensile and flexural properties were tested as follows: Tensile properties using a Lloyd tensile machine, type LR5K+ equipped with 500 dN load cell. Izod impact strength using a Ceast Impact Tester. Hardness measurements were conducted using two durometers: scale Shore D for UPVC and scale Shore A for PPVC. Accelerated weathering process was conducted in an Atlas Weather-O-meter model CI 3000+ and then tensile properties were evaluated. All tests were conducted according to the ASTM standards

Results and Discussion

As expected, the density of the composite increases as the mass fraction of the fiber increases.

The presence of the fiber caused a decrease in the softening temperature of UPVC, whilst the addition of the silane had a reversed effect. This might be due to the weak adhesion between the fiber and the matrix, which caused the interface to soften at a lower temperature; the silane had stiffened the adhesion, or even resulted in the creation of an interphase with a higher softening temperature.

The addition of the glass fiber to PPVC gave a slight decrease in the volume resistivity, where the volume resistivity of the fiber is lower than that of the PPVC.

The increase in the fiber content resulted in an increased the hardness of the PPVC, whilst it had no effect on the UPVC hardness. The silane addition had no effect.

The impact strength of the UPVC showed a gradual increase with the increase of the fiber content. The silane treated samples had a higher increase in the impact strength. This is attributed again to the increase in the bonding strength between the fiber and the polymeric matrix (Figure 1).

The addition of the fiber to the UPVC resulted in an increase in the flexural modulus. Moreover, the silane treated samples showed more increase than the untreated samples.

The composite displayed an increase in tensile modulus upon the increase of the fiber; this increase was much higher in the case of PPVC: the fiber addition caused that the modulus of the PPVC composite to be higher than the UPVC composite. This is attributed to the better wetting and bonding of the fiber with the PPVC polymer than with the UPVC that resulted in a better stress transfer between the matrix and the stiff fiber.

The tensile strength of PPVC composite showed an increase with the addition of the fiber except for the GM addition which did not show any effect. There was again a higher increase with the addition of the silane. For the case of the UPVC composites; the GM and GT fibers addition resulted in decrease of the strength. This is due to the weak adhesion between the fiber and the matrix and the formation of small cavities that acted as stress concentrators and resulted in an early interface separation. The strength showed an increase with the RC fiber. The silane samples displayed a higher increase (Figure 2).

The addition of the fiber resulted in a decrease in the elongation. The silane treated samples showed a lower decrease in elongation.

The weathering effect

During weathering of the PPVC, different processes take place simultaneously that affects the properties of the polymer: elimination of HCl, degradation, discoloration, and cross-linking [2]. To test the effect of the weathering on the PPVC, samples were aged in the weathering chamber and tested after 120 and 480 hours. The modulus of the PPVC increased as the weathering period increased for both of silane treated and untreated samples.

The strength showed an increase as weathering period prolonged for the RC and GT fibers with the shoe formulation. However, the increase for the GM fiber with the cable formulation was limited and even at high fiber content there was a decrease at the 120 hr period. Moreover, the strength decreased with the increase of the fiber content for this type of composite in contrary to the other two tested types. Silane treated samples were higher in strength in general.

The elongation at break decreased with the increase of the weathering period. Again, the elongation was higher for the silane treated samples.

Conclusion

In this research, the glass fiber-PVC composite showed different physical and mechanical properties depending on the form of the fiber, the volume fraction of the fiber, the PVC formulation and the presence of a coupling agent. All these factors are affecting the adhesion between the fiber and the matrix and hence the properties. It is therefore recommended to test each composite combination by itself before its deployment and especially in the case of outdoor exposure.

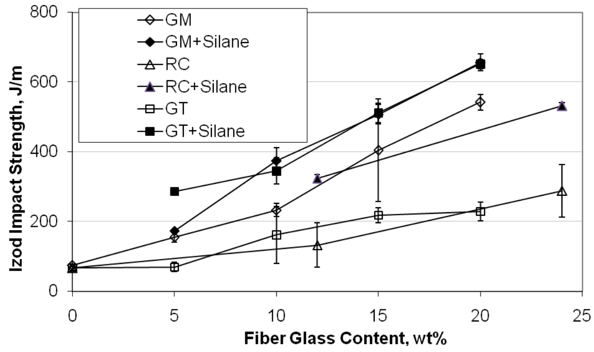

Figure 1; Izod impact strength for UPVC composites[1].

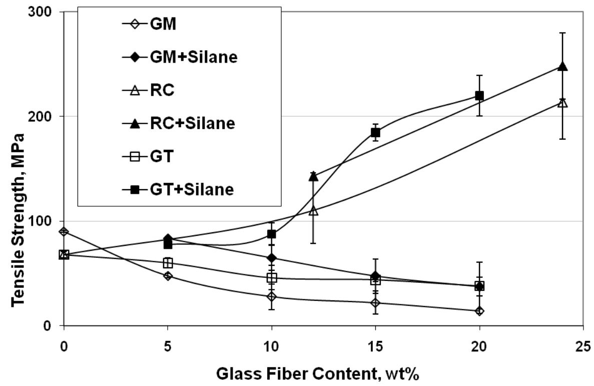

Figure 2; Tensile strength for UPVC composites[1].

References:

1. Soo-Jin Park, Joong-Seong Jin, Journal of Colloidal and Interface Science, 2001, 242, 174-179.
2. J. White, A. Turnbull, NPL report, 1992, DMM(A), 75.

[1] **For the RC and GT fibers, the PVC was pipe formulation, for the GM the PVC was the profile formulation.**