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DYNAMIC RHEOLOGICAL PROPERTIES OF PC/ABS BLENDS AND PC/ABS/GF COMPOSITES

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ABSTRACT
For mechanical properties improvement of PC/ABS blends a filler reinforcement (glass fibres in our case) might be used. The present work focused on dynamic rheological behaviour, which is sensitive tool for studying physical nature of polymer blends and composites. Viscoelastic properties of PC/ABS blends (prepared in several compositions) and PC/ABS/glass fibber composites were investigated. The effect of various methods of samples preparation has also been considered.
Keywords: blend, acrylonitrile-butadiene-styrene, polycarbonate, glass fibres and rheology.

1. INTRODUCTION
Polycarbonate (PC)/acrylonitrile-butadiene-styrene (ABS) blends offer impact and heat resistance of polycarbonate together with good processability and low cost of ABS. An improvement of their mechanical properties (specially increase of stiffness and strength) in the process of cost-rice absence, might be reached by reinforcement with short fibres. At present, it is general trend to use fast, not expensive and continuous producing processes, which mostly involve flow patterns leading to fibre orientation. Since fibre content together with flow conditions influence the final arrangement of fibres in matrix, rheological properties are of a key importance during processing [1-3].
In this paper, experimental results of dynamic rheological properties of PC/ABS blends and PC/ABS/GF composites are presented. Influence of processing methods, comparison of compression moulding and injection moulding, fibre content and fibres alignment on flow properties were investigated.

2. EXPERIMENTAL
2.1. Materials and sample preparation
Polycarbonate (PC) Iupiron S3000NF (Mitsubishi Engineering Plastics Co. Ltd., Japan) and acrylonitrile-butadiene-styrene (ABS) TFX 170NP (Techno-Polymer Co. Ltd., Japan) were used for polymer blends and composites preparation. The ABS content in PC/ABS blends was 0, 20, 40, 60, 80 and 100 wt.%. Blends were denoted by codes, e.g. blendXY, X corresponds to content of PC and Y to ABS content. The blend64 (i.e. 60PC/40ABS) was used as the matrix for composites preparation. In these cases, glass fibres with diameter 12 μm were employed as a filler. Composites with three different fibre contents were produced. They were labelled as CMP1, CMP2 and CMP3 where fibre weight fractions are 10, 22.2 and 31.6 wt.%, respectively.
Dried and weighted amounts of components were dry-blended, melt-mixing in a twin screw extruder (TEX 30α, Japan Steel Works Co. Ltd., Japan) at screw speed 260 rpm and temperature 260 °C along whole cylinder followed. Extrudates were cut into pellets, dried, and then specimens manufacturing followed either by compression moulding (CM) or injection moulding (IM). In the former case temperature 260 °C and pressure 9.8 MPa was used, in the latter, temperature 240 °C was set. In both cases rectangular sheets were produced, from which round specimens for rheological measurements were cut.

2.2. Fibre content and fibre length distribution in the samples

Weight content (Φ_f) of glass fibres was determined gravimetrically after matrix incinerating. Glass fibre volume content (V_f) was calculated from the components densities. In order to examine the fibre length distribution, incineration residue was separated into filaments, which were spread on the glass desk and the photomicrograph pictures were taken. From these photographs, the length of filaments were measured and the fibre length distribution in the specimens was computed.

2.3. Rheometry

Oscillatory flow properties, such as storage modulus (G′), loss modulus (G″) and complex viscosity ($|\eta^*|$), were determined in rotational rheometer (ARES Rheometrics, USA) with a parallel-plate geometry (plate diameter 25 mm, gap between plates 1 mm) equipped with RSI orchestrator software package. Measurements were carried at 240 °C, at strain (γ_o) 1% and angular frequencies (ω) in the range from 0.1 to 100 rad/s.

3. RESULTS AND DISCUSSION

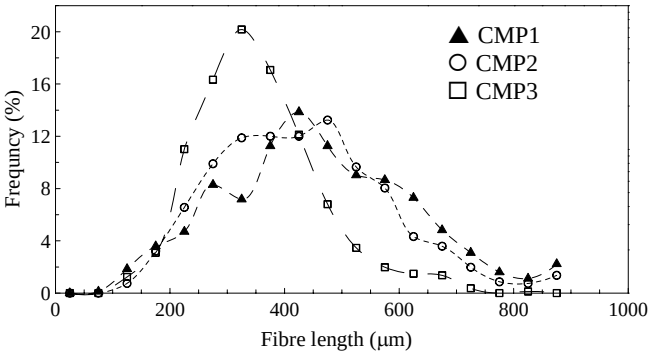
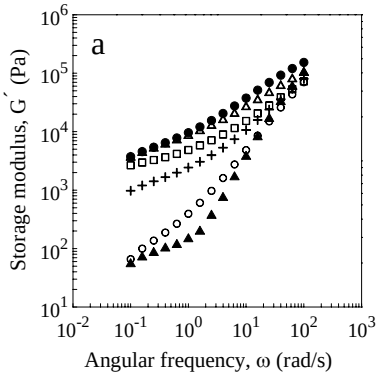


Figure 1. Fibre length distribution of glass fibre filled blend64.



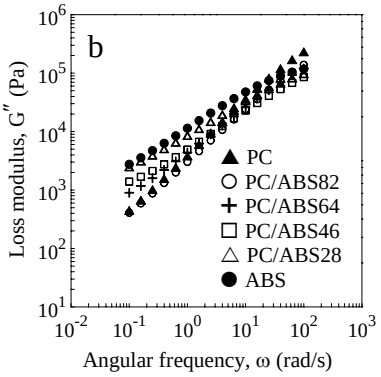


Figure 2. (a) Storage and (b) loss moduli as a function of angular frequency for pure materials and PC/ABS blends prepared by IM.

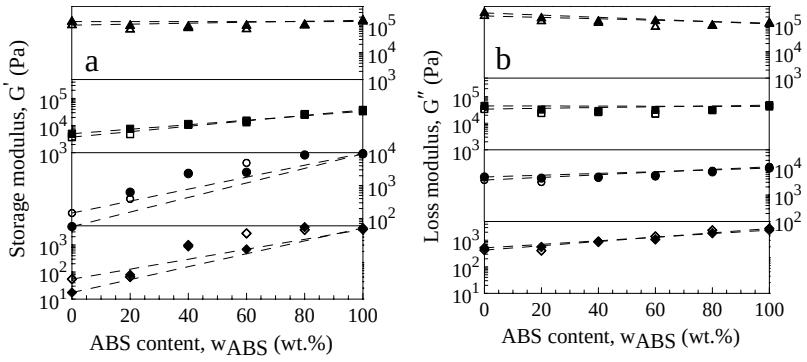


Figure 3. (a) Storage and (b) loss moduli as a function of ABS content for PC/ABS blends prepared by IM (open symbols) and CM (solid symbols) at various angular frequencies (rad/s): 0.1 (◇◆); 1 (●○); 10 (□■); 100 (△▲).

3.1. Fibre content and fibre length distribution in the samples

Table 1 gives fibre content and parameters characterizing fibre length distribution in composite materials, and fibre length distribution curves are depicted in Figure 1. The fibre length decreases and the fibre distribution becomes narrow with increasing fibre content.

Table 1. Composition and fibres length distribution in the composites.

Code	Weight fraction of fibres Φ_f (%)	Volume fraction of fibres V_f (%)	Number-average of fibre length I_N (μm)	Weight-average of fibre length I_W (μm)	Polydispersity index I_W / I_N	Aspect ratio
CMP1	10.0	4.7	459	520	1.13	38.2
CMP2	22.2	11.3	433	486	1.12	36.1
CMP3	31.6	17.1	354	388	1.10	29.5

3.2. Rheometry of PC/ABS blends

All measurements were done in linear viscoelastic region. Viscoelastic properties of injection moulded PC/ABS blends and pure PC and ABS as a function of angular frequencies are shown in Figure 2. Pure PC and blend82 exhibits, in the whole measuring range, higher lose of storage modulus values. The difference between moduli, which reached at low angular frequencies almost one decade, is reduced with increasing ω. For the remaining blends and pure ABS predominant elastic behaviour was observed.

Comparison between IM and CM samples preparation methods is demonstrated in Figure 3 depicting dependencies of storage (a) and loss (b) moduli on ABS content. In most cases, G' and G" followed mixing rule, and nearly identical values of IM and CM moduli were obtained. Different situation occurred at 0.1 and 1 rad/s, where storage modulus varied more with type of preparation methods than loss modulus. Furthermore, positive deviation of G' observed for composition range 40 – 60 wt. % ABS might be attributed to possible phase transition.

Influence of glass fibres content is discussed in Figures 4 and 5. In the former, storage (a) and loss (b) moduli of IM and CM samples are plotted as function of glass fibres content at four angular frequencies, and in the latter, relative storage (a) and loss (b) moduli were calculated to emphasize influence of fibre content in composites. Both rheological functions of glass fibre reinforced materials are higher in comparison to that of plane blend64. The reinforcement build-up led to moduli increase. As already mentioned above, almost no difference between moduli of PC, ABS and blends prepared by injection moulding and compression moulding were observed. Different situation occurred for blend64, when glass fibres as filler at several concentrations were used. Moduli of injection moulded composites were for all measured angular frequencies higher than moduli for compression moulded ones. Furthermore, moduli of both IM and CM composites differ more with increasing fibres content. This can be explained by possible higher fibre orientation which occurs in the injection moulded samples. It was also observed that the largest differences between moduli of injection and compression moulded composites were reached at the lowest employed angular frequency.

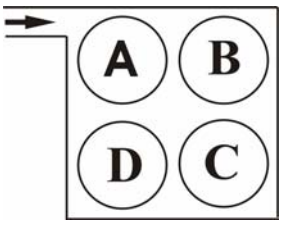


Figure 7. Schema of samples position in injection moulded sheets.

In Figure 6 viscoelastic properties of injection moulded samples, which were cut out from different positions of injection moulded sheets are compared. Schema of samples location in IM sheets is depicted in Figure 7. For blend64 and CMP1 no detectable differences between position B and D were obtained. For CMP2 loss and storage moduli of position B and D slightly differed, and in case of CMP3 the most pronounced differences between moduli of position B and D from all measured cases were obtained. The influence of samples position increased with increasing fibre content.

4. CONCLUSION

The results obtained for influencing factors can be summarized as follows:

- sample preparation: viscolelastic properties of pure PC, ABS and their blends were only slightly influenced by the type of samples preparation. Small variances were observed only for low angular frequencies (0.1 and 1 rad/s) between storage moduli of IM and CM samples.

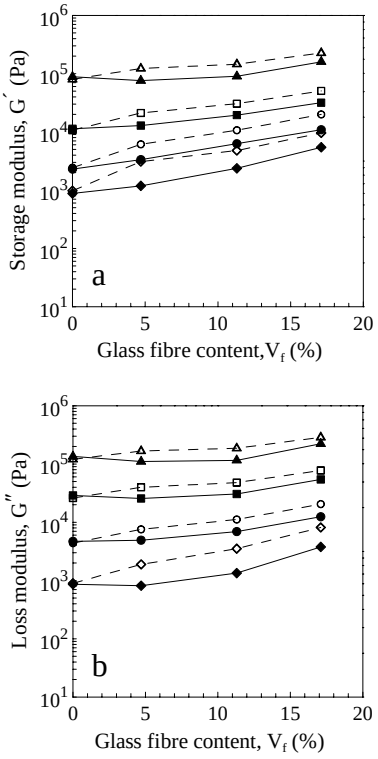


Figure 4. (a) Storage and (b) loss moduli of glass fibre filled PC/ABS blends prepared by IM (open symbols) and CM (closed symbols) as a function of GF content at various angular frequencies (rad/s): 0.1 (◇◆); 1 (●○); 10 (□■); 100 (△▲).

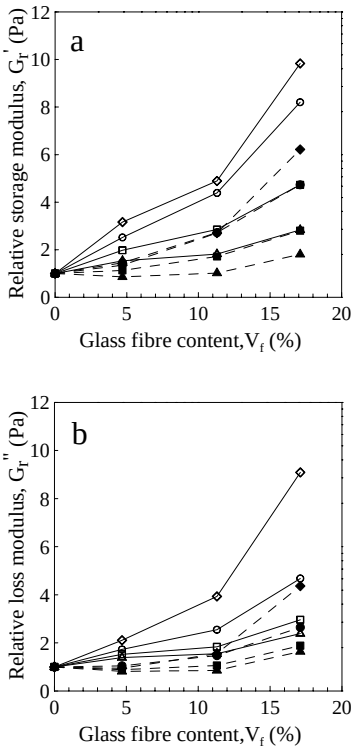


Figure 5. (a) Relative storage and (b) loss moduli as a function of glass fibre content for IM (open symbols) and CM (closed symbols) samples at various angular frequencies (rad/s): 0.1 (◇◆); 1 (●○); 10 (□■); 100 (△▲).

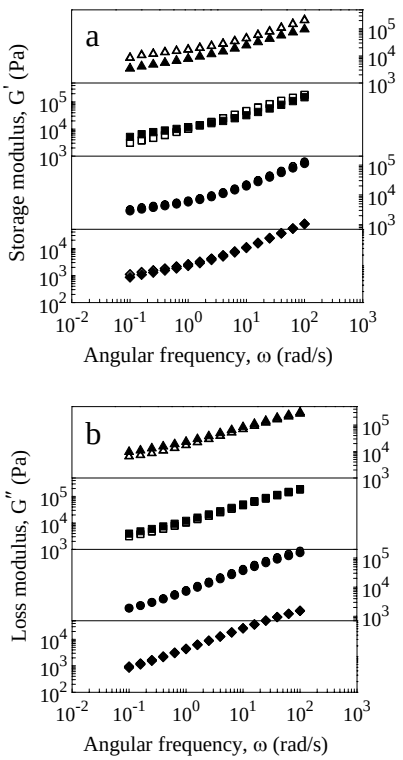


Figure 6. Comparison of (a) storage and (b) loss moduli at positions B (open symbols) and D (closed symbols) of IM samples for GF filled blend64 as a function of angular frequency at various GF volume content (%): 0 (◇◆); 4.3 (●○); 11.3 (□■); 17.1 (△▲).

For glass fibre-filled composites, on the opposite, the way of composite preparation is important.
- fibre content: increasing fibre content enhanced all composites properties under examination. Further, the differences between IM and CM samples are more significant at higher fibre content. Such results are due to the different level of fibres alignment corresponding to the type of sample preparation, and fibre content.

5. ACKNOWLEDGEMENT

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