ESRF

Experiment title:

The interplay between rubber modified and deformation mechanism in toughened acrylics

Experiment number:

SC73

Beamline:

ID2

Date of Experiment:

from: 26.10.1995 to: 28.10.1995

Date of Report:

26.07.1996

Shifts:

6

Local contact(s):

Oliver Diat

Received at ESRF:

0 5 AUG 1996

Names and affiliations of applicants (*indicates experimentalists):

Dr A. M. Donald Cavendish Laboratory, University of Cambridge, UK
Dr C. He* Cavendish Laboratory, University of Cambridge, UK
Mr. M Butler* Cavendish Laboratory, University of Cambridge, UK
Mr T. Waigh* Cavendish Laboratory, University of Cambridge, UK
Ms A Magalhaes Universidade de Minho, Portugal

Report:

Rubber toughening of polymethyl methacrylate (PMMA) is a frequently used strategy to overcome the normal brittle response to deformation. Modern polymerisation methods have led to the possibility of preparing rubber particle with a range of different internal morphologies: they may contain several alternating layers of rubber and PMMA, and the properties of the rubber itself can be altered, for instance by crosslinking. However, understanding of how changing this structure may affect subsequent deformation mechanisms is somewhat rudimentary. Small angle X-ray scattering (SAXS) is potentially useful for studying the deformation microstructure; not only does this method have none of the disadvantages which transmission electron microscopy usually has, but the use of high intensity synchrotrons radiation allows the possibility of an *in-situ* deformation study. In our studies at Grenoble in October, 1995, we examined the response of core shell rubber toughened PMMA to tensile deformation and studied the influence of the form factor in influencing the invariant analysis. The results of this research was written as two papers for publication (refs: 1 and 2)

Figures la is the 2-D SAXS pattern of underfomed sample with 4070 (w/w) of rubber particles. It can be seen that there are several rings in the scattering pattern. Although the intensities of each change between samples with different rubber particles concentration (here only one sample is shown), the position of the rings is the same. The positions of the rings are insensitive to the concentration of rubber particles, suggesting that their origin lies in the density fluctuation of the composite particles. This scattering can be compared with the calculated particle form factor (given the known particles' internal structure) and good agreement is found. With increase of tensile strain, the shape of the SAXS pattern changes gradually from a circle to an ellipse, indicating a progressive deformation of particles, as shown in Figure lb. The intensities of two reflections concentrate on the meridional increase with increasing strain. As the strain increases further, the intensities of the two meridional reflections become more intense and at the same time the outher scattering rings become blurred as shown in figures le. Furthermore, a four point scattering pattern can also be seen at very low angles, whose position corresponds to the particle radius, as shown in figure lc. Computer simulation shows that the appearance of scattering on the meridional is due to the inhomogeneous deformation of the rubber particle while the occurrence of blurring is the result of debonding or cavitation beyond the yield point. Detail of this result was reported in reference 1.

As mentioned previously, the form factor of the rubber particle dominates the low angle scattering, which has been used to aid understanding the deformation of rubber particles in a polymer matrix. However, this strong low angle scattering also hinders the quantitative analysis of the invariant from any crazes. We have studied the influence of the form Factor and the deformation of rubber particles on invariant analysis. It is shown that, for a sub micron rubber particle system, the scattering from the form factor for core shell rubber particles dominates the SAXS pattern, and the intensity of this scattering increases as the concentration of rubber particle increases. This scattering needs to be subtracted from the experimental data before the invariant can be quantitatively analysed for the amount of crazing upon deformation. The deformation of the core shell rubber particles increases the contribution of the form factor to the total invariant, although this effect is fairly minor compared with crazing. This result was reported in reference 2.

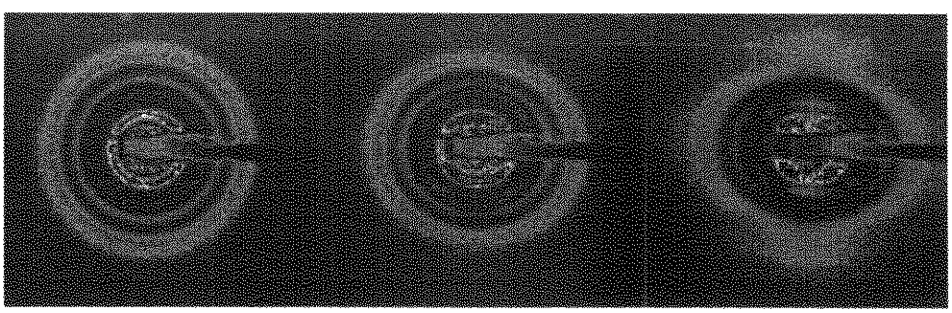

Figure la **Figure lb** **Figure lc**

Figure 1: 2-D SAXS of deformed rubber toughened PMMA with 40 wt.-% of rubber particles; a) undeformed; b) extension of I mm and c) extension of 1.75 mm. tensile axis: vertical

References

1) *In-situ* Deformation Studies of Rubber Toughened PMMA: A SAXS Analysis of the Response of Core Shell Particles to Deformation

Authors: Chaobin He, Athene M Donald, Michael Bulter and O,Dait

Macromolecular Symposium, Accepted for publication

2) *In-situ* Deformation Studies of Rubber Toughened PMMA: Influence of Rubber Particle and Their Deformation in Invariant Analysis

Authors: Chaobin He, Athene M Donald, Michael Butler and O.Dait

Macromolecules (submitted)