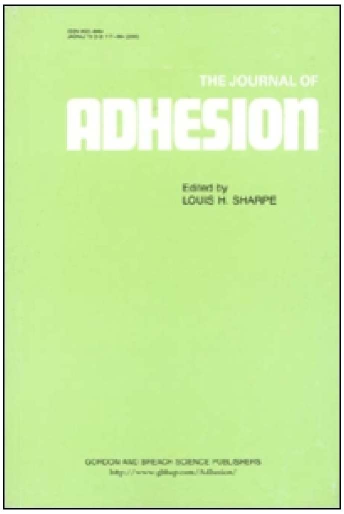

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Comments on "Fatigue Performance of Two Structural Adhesives" [*J. Adhesion* 26, 273-291 (1988)]

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Comments on "Fatigue Performance of Two Structural Adhesives" [*J. Adhesion* 26, 273–291 (1988)]

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Since we at Imperial College also have an extensive research programme concerned with the fatigue performance of structural adhesives and adhesive joints, I read with interest the paper[1] on the "Fatigue Performance of Two Structural Adhesives".

Essentially, the authors propose that "adhesive 21" (a two-part, cold-cure, rubber-toughened epoxy adhesive) exhibits a crazing micromechanism. In contrast, "adhesive 16" (a one-part, heat-curing rubber-toughened epoxy adhesive) exhibits a shear yielding micromechanism. These different micromechanisms are then suggested as explanations for the different fatigue behaviour which was recorded for the two adhesives. This is not an interpretation we at Imperial College would place on their results.

The main evidence for the proposed crazing mechanism in "adhesive 21" appears to be the observation of stress whitening in the neighbourhood of the fatigue crack tip. However, it was established many years ago[2–9] that the presence of stress whitening in typical rubber-toughened epoxy polymers arises not from a crazing micromechanism but from cavitation of the rubber particles with possible debonding of the rubber particles from the epoxy matrix. This cavitation and/or debonding of the rubber particles accompanies the extensive **shear yielding** that occurs in the epoxy matrix. The extensive shear yielding is initiated, of course, by the presence of the rubber particles and is the main energy-dissipative mechanism. It should be noted that, whilst shear yielding always occurs in the neighbourhood of the crack tip, it is not always accompanied by particle cavitation/debonding; *i.e.* stress whitening is not necessarily observed in every rubber-toughened epoxy. The exact details of this complex micromechanism, and the effects of factors such as the microstructure of the epoxy and test conditions, are to be found in the literature.[2–9]

Indeed, from the many studies that have been conducted on identifying the micromechanisms of fracture in thermosetting epoxy polymers there is no positive evidence whatsoever of crazing. These detailed experimental observations have been supported by theoretical work which demonstrates that highly crosslinked polymers, such as typical epoxy adhesives, do not possess the chain mobility and extensibility necessary for craze structures to form.[10]

Our current work on the fatigue performance of rubber-toughened structural adhesives reveals that the micromechanism of fatigue crack growth is similar to that observed in the previous fracture experiments. Namely, that any stress whitening which is observed arises from cavitation of the rubber particles and that the main deformation micromechanism observed in epoxy adhesives is one of shear yielding; no evidence for a crazing micromechanism having been found. Indeed, previous work[11] on fatigue crack growth in rubber-toughened epoxies also concluded that there was no evidence for crazing.

I think that stress whitening in "adhesive 21" is most unlikely to be the result of crazing. Therefore, unless there is conclusive evidence for a crazing micromechanism in "adhesive 21", the measurements on the fatigue crack growth reported by Luckyram and Vardy are better re-interpreted without recourse to a "crazing *versus* shear yielding" argument.

References

1. J. Luckyram and A. E. Vardy, *J. Adhesion* **26,** 273 (1988).
2. W. D. Bascom, R. L. Cottington, R. L. Jones and P. J. Peyser, *J. Applied Polymer Sci.* **10,** 2545 (1975).
3. A. J. Kinloch, S. J. Shaw, D. A. Tod and D. L. Hunston, *Polymer* **24,** 1341 (1983).
4. L. C. Chan, J. K. Gillham, A. J. Kinloch and S. J. Shaw, in *Rubber-Modified Thermoset Resins,* C. K. Riew and J. K. Gillham, Eds. (American Chemical Soc, Washington DC, 1984), p. 261.
5. A. J. Kinloch, D. Maxwell and R. J. Young, *J. Materials Sci. Letters* **4,** 1276 (1985).
6. A. F. Yee and R. A. Pearson, *J. Materials Sci.* **21,** 2462 (1986).
7. A. G. Evans, A. B. Ahmad, D. G. Gilbert and P. W. R. Beaumont, *Acta Metall.* **34,** 79 (1986).
8. A. J. Kinloch, in *Structural Adhesives,* A. J. Kinloch, Ed. (Elsevier Applied Science, London, 1986), p. 127.
9. R. J. Young, in *Structural Adhesives,* A. J. Kinloch, Ed. (Elsevier Applied Science, London, 1986), p. 163.
10. E. J. Kramer and C. S. Henkee, *J. Polymer Sci., Polymer Phys.* **22,** 721 (1984).
11. D. N. Shah, G. Attalla, J. A. Manson, G. M. Connelly and R. W. Hertzberg, in *Rubber-Modified Thermoset Resins,* C. K. Riew and J. K. Gillham, Eds. (American Chemical Soc, Washington DC, 1984), p. 117.