AGEING OF STRUCTURAL FILM ADHESIVES - CHANGES IN CHEMICAL AND PHYSICAL PROPERTIES AND THE EFFECT ON JOINT STRENGTH

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Epoxy-based film adhesives are extensively used in structural aircraft applications but although the one part nature of these materials has many advantages in terms of ease of use, the short shelf-life can be a serious disadvantage, especially when the material spends lengthy times in transit between manufacturer and user. Studies on a number of epoxy and nitrile-epoxy adhesives have shown that slow cure, hydrolysis of the resin and specific interactions between components can occur during storage which result in modification of various chemical and physical properties of the uncured adhesives. The relative importance of these reactions depends on the adhesive composition. These modifications are reflected in changes in the strength of joints made with aged adhesives. This paper presents examples of these effects drawn from the results of a number of ageing studies.
INTRODUCTION

Many of the adhesives used for structural applications in aircraft are in the form of one part films of very limited shelf life, even when stored at low temperatures. The increasing use of bonding in critical areas, including primary aircraft structure, has focussed attention on the nature of the reactions which occur during storage, chemical methods of assessing the extent of these reactions and the effect of such reactions on the joint strength of the cured material. These considerations are of particular concern in Australia since all adhesives of this type are imported and must be transported long distances from the point of manufacture. In addition, the usage of particular adhesives is quite small so that means of extending the usable life are of interest.

Considerable efforts by many workers have been devoted to the establishment of chemical methods of characterising epoxy-based adhesives and composite prepregs for the purposes of quality control. Some attention has also been given to the (adverse) effects of a high humidity atmosphere on the properties and cure characteristics of adhesives and prepregs. While some consideration has been given to certain aspects of the ageing of these materials, little attention seems to have been paid to an overall study of the changes in the chemical and physical properties of adhesives during storage on the one hand and the strength of joints made with aged adhesives on the other.

This paper summarises the results of a number of ageing studies on two classes of film adhesives: 177°C curing, epoxy systems and 121°C curing, nitrile-epoxy systems. Several types of reactions have been identified and their effects on joint strength considered.

EXPERIMENTAL

Examples of two classes of film adhesives have been studied: (a) epoxy-based, 177°C - curing systems, designed for metal-to-metal bonding in aerospace applications, for service up to about 200°C and (b) nitrile rubber modified epoxy systems, 120°C - curing, designed for aerospace metal-to-metal bonding for service up to about 100°C.

For ageing, adhesive specimens were stored in polyethylene bags at about 23°C. Samples were removed at intervals for testing or, if necessary, stored at -18°C until required.

For high pressure liquid chromatography (HPLC) a modified