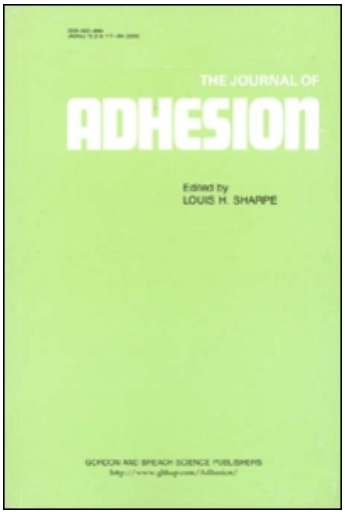

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Effects of Interfacial Structure on the Mechanical Properties of Epoxy Resin and Poly(vinyl chloride) Modified with Crosslinked Poly(methyl methacrylate) Particles

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(Accepted for publication 13 July 2000)

The effect of interfacial adhesion on the mechanical properties of an incompatible polymer blend was investigated. For this purpose, the preparation of uncrosslinked and crosslinked poly(methyl methacrylate) particles having mean sizes of about 0.8 μm was completed by a seeded emulsion polymerization, and amount of crosslinked points in the particles were varied. The obtained emulsion particles were powdered by a freeze dry method and dispersed into poly(vinyl chloride) matrix, as typical ductile polymer, by a melt blending. The mutual diffusion of the polymer molecules at particle/matrix interfacial regions was restricted by the crosslinked points, because of poly(methyl methacrylate) has a good compatibility with poly(vinyl chloride). And then, the good interfacial adhesion was obtained at the optimum amount of crosslinked points in the particles. The yield stress and the fracture toughness never decreased, when the interfacial adhesion is sufficient. Subsequently, the particles were dispersed into epoxy resin, as typical brittle polymer, which has also a good compatibility with poly(methyl methacrylate). However, the good adhesion was never obtained in the epoxy system, therefore, the fracture strength and the fracture toughness decreased with the incorporation of particles.

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Modification of Epoxy Resin with Ethylene-Based Copolymer

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Epoxy resin was modified with ethylene-based copolymer. Two types of ethylene-based copolymers were used in this study; ethylene acrylic rubber and ethylene-based ionomer/clay nanocomposite. For the ethylene acrylic rubber-modified epoxy, three types of hardeners were used and the effect on microstructure and mechanical properties (dynamic viscoelasticity and fracture toughness) was investigated. The hardener considerably affected the microstructure, and this led to the differences in dynamic mechanical properties. The fracture toughness values were not so much improved. For the ionomer/clay-modified epoxy, effect of hardener content on mechanical properties was investigated because ionomer is expected to react with epoxy resin. The dynamic viscoelastic tests showed that the glass transition temperature (T_g) was increasing with decreasing the hardener content. For one resin system, the T_g disappeared and thermal resistance was greatly improved. Fracture toughness was decreasing with decreasing the hardener content. In particular, the fracture toughness value of the system without T_g was 40% less than that of the unmodified system. These results can be explained by increase of crosslink in epoxy matrix which were caused by the reaction with epoxy and ionomer.

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Synthesis and Properties of Novel Epoxy Resins Having Siloxane Units (I)

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(Accepted for publication 26 July 2000)

Synthesis and properties of novel siloxane-modified epoxy resins (ESDGs) were studied. These epoxy resins were synthesized by the reaction of bisphenol-A type epoxy resin having allyl group with hydride terminated polydimethylsiloxanes. ESDGs were mixed with a commercial epoxy resin (DGEBA) in various ratios. The mixed resins were cured with triethyleneglycoldiamine. The effect of the amount of siloxane units on toughness, heat-resistance and adhesive properties of cured resins were investigated. The addition of 10 wt% ESDG resulted in a 40% increase in the toughness (K_{1c}) without reducing heat resistance. SEM showed that the improvement depended on the microphase-separated structure. Peel strength of adhesives were improved by the addition of ESDG.

(Received 5 June 2000)

Modification of Epoxy Resin with Thermoplastic Polyurethane Elastomers: The Effects of Hard Segments of the Elastomers on Properties of Cured Epoxy Resin

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(Accepted for publication 28 August 2000)

The relationships between morphology and physical properties of cured epoxy resins blended with thermoplastic polyurethane elastomers (TPUs) were investigated. TPUs with hard segment/epoxy resin blends were prepared by a *in-situ* polymerization method in the epoxy resin. Adhesion properties of Fe/Fe joint using TPU/epoxy resin blends,

bending properties and fracture toughness of cured ones were improved as compared with unblended epoxy resin and they were affected by the amount of TPUs and molecular weights of macro-glycols. The results of dynamic viscoelastic properties, thermal analysis and scanning electron microscopy photographs of fracture surfaces of cured TPU/epoxy resin blends showed that the morphologies of the cured blends were varied by the amount of TPUs, molecular weights of macro-glycols and the presence of hard seguments in TPUs.

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The Behavior of Residual Stresses on Epoxy Bonded Structures during Curing Process

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Chemical curing-shrinkage and thermal mismatch generated the residual stresses on bonded structures during curing process and heat cycle process. Evaluating of residual stress is necessary to make sure of the reliability of equipments. But the behavior of residual stress in bonded structures is not cleared. In this study, the residual stress of epoxy adhesives was measured by the bimetal specimen during curing process and heat cycle process. In this experiment, room temperature (20°C) curing and 50°C after curing were given. Moreover, heating and cooling cycles were given. Relationship between the residual stress and temperature was obtained. As a result, following conclusions were obtained: [1] Chemical curing-shrinkage increases the residual stress during room temperature curing. [2] Retained chemical curing-shrinkage increase the residual stress during heating process of after curing, [3] In case of after curing, the residual stress during heating process is not equal to that during cooling process, because a coefficient of thermal expansion of resin during heating process is larger than that during cooling process. [4] Maximum residual stress generate after cooling process of after curing.

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Properties of Silica-Epoxy IPN Composites

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(Accepted for publication 25 August 2000)

Silica-polyacrilic acid (PAA)-epoxy IPN and Silica-epoxy IPN were prepared using the phase separation during the sol-gel transition of alkoxysilane-PAA system. The silica-PAA IPN or silica skeleton prepared by heat treating the silica-PAA IPN at 600°C or 800°C were soaked with epoxy resin to prepare silica-PAA-epoxy IPN or silica-epoxy IPN. Thermodynamic properties of these IPNs have been investigated. The storage modulus (E′) of these IPNs prepared with two different types of epoxy resin remained high even at the temperature range over the glass transition. In addition, silica-PAA-epoxy IPN showed high loss modulus (E″) at about 300°C. The high E″ value suggests that the silica network protects the polymer at high temperature. The thermogravimetric measurements have confirmed the protection effect of silica network against the thermal decomposition.

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Synthetic Resins: 'New Materials' on Art Making — Four Practical Studies Focusing on Epoxy Resin

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Comparing with 'real' art materials such as woods, stones, and metals, the current evaluation toward synthetic resins such as epoxy resin is unbelievably low; Many artists believe blindly synthetic resins are just 'cheap' substitutes for 'real' materials and don't even try to know their real characteristics... Especially, epoxy resin has been left in the miserable situation... only few know how to use it. ...This is definitely unfair.

This paper is an attempt to shed light on the awful underestimation toward synthetic resins through four practical studies, taking epoxy resin as an example. Through this research, it is clearly showed that synthetic resins possess high potentiality as art materials and further rich possibility to open new horizon of Art making.

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Estimation of Shear Strength by Using Cruciform Joints

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The estimation method of the shear adhesive strength was studied using the biaxial testing machine and cruciform adhesive joints. An epoxy resin was used as the adhesive. Material constants of adhesive were measured using adhesive bulk specimens to harden adhesive simple substance. Combined stresses were loaded by bulk specimens. From this

result, the von mises yield criterion can be used for this adhesive. A elastic-plastic analysis was done by the finite element method (FEM) using the von mises yield criterion. Stress distributions of the adhesive layer of the cruciform joint were evaluated by FEM. Regardless of the load ratio, distributions of three normal stresses on the adhesive layer agreed approximately. Therefore, shear stresses control the von Mises equivalent stress. If the stress condition of the adhesive layer can be evaluated with the equivalent stress, cruciform joints fracture mainly by the shear stress. And the resultant shear stress in fracturing becomes constant regardless of the loading rate. Thus, Biaxial loading tests were done. The experiment result agreed with the analysis result. The strength of the cruciform joint, the torsional strength of the bulk specimen and that of the cylindrical butt joint was compared. These strength agreed approximately. From above-mentioned result, in case of the adhesive which can use von mises yield criterion, it is possible to evaluate a shear strength by this evaluating method.

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Fatigue Analysis of Micro Resist Pattern Analyzed by the Direct Collapse Method with Atomic Force Microscope

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(Accepted for publication 17 May 2000)

The destruction load of the micro resist pattern is measured quantitatively by means of applying load with an atomic force microscope (AFM) tip. By the fatigue effect, the dot-shaped pattern of 160 nm in diameter, to which the constant load is applied repeatedly with the AFM tip, is destructed. The destruction load without fatigue effect is approximately 90 nN. However, with fatigue effect, the pattern destruction occurs even at lower load, 1.3 and 53.1 nN. The results indicate the pronounced fatigue effect by increasing the applying load until 105 nN. This method can be useful for the quantitative analysis of fatigue effect in micro scale.

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Effect of Adherend Thickness on Joint Strength of Double Lap Joint

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Shear stress and normal stress act on adhesive layer of double lap joint. It is known that the shear stress distribution becomes flat and joint strength increases as adherend thickness increases. In this study, compression and tension tests of double lap joint were carried out in order to clarify the effect of adherend thickness on joint strength. Shear stress distribution acting on the adhesive layer under tensile force and that under compressive force are the same. On the other hand, compression test and tension test differ from each other in direction of normal stress acting on the adhesive layer.

From comparison of the joint strength under compression test with that under tension test, it was observed that large deterioration of the joint strength occurred as adherend thickness becomes large due to the normal stress which was provided in the adhesive layer when the double lap joint was subjected to tensile force. The strength deterioration increases in proportion to an increase in adherend thickness.

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Toughening of Aluminum Hydroxide Filled Acrylic Composite

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(Accepted for publication 23 August 2000)

The microscopic study suggested that the destruction of aluminum hydroxide filled acrylic composite proceeded inside of the particle. Therefore, the protection of the brittle particle from the cleavage was important for toughening of this system. This purpose was achieved by addition of newly prepared carboxyl terminated unsaturated polyesters having flexible segment to the composite. These polyesters contained both carboxyl and vinyl groups, therefore they were absorbed selectively by the basic surface of aluminum

hydroxide and gave the elastic layer by crosslinking. In addition, these modifiers were copolymerized with the matrix acrylic resin, and hence the strong adhesion between the elastic layer and the matrix toughened the composite more effectively. Consequently, this work provided the concept for toughening of aluminum hydroxide filled acrylic composite, and proposed an efficient toughening method.

The effect of these impact modifiers was detected at the fracture surface of the composite and characterized by scanning electron microscope (SEM) observation and elemental analysis which were given by energy-dispersed X-ray micro-analyzer equipped with the SEM (SEM-EDX analysis).

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Studies on New Type of Phenolic Resin by Ring Opening Reaction of Benzoxazine (X) – Effect of Molecular Weight of Matrix on Properties of Glass Fiber Reinforced Composites

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Two kinds of phenol-novolac based benzoxazine having different molecular weights were synthesized. Glass fiber reinforced plastic (GFRP) was prepared using the molten mixture from the above benzoxazines and bisoxazoline as a matrix, and the effect of molecular weight of benzoxazines on the properties of GFRP was investigated. As a result, GFRP from the benzoxazine having larger molecular weight as a matrix showed higher heat resistance because of higher crosslink density. And GFRP from the benzoxazine having lower molecular weight as a matrix showed higher tensile, flexural and especially impact strength. The reason was considered as follows: in the case of the benzoxazine having lower molecular weight as a matrix, matrix was so flexible due to lower crosslink density, and interfacial bonding strength between matrix and fiber was so low that stress concentration in matrix was easy to relax.

(Received 8 June 2000)

Effect of Humidity in Corona Discharge Treatment on Adhesive Strength of Polyethylene Sheet

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(Accepted for publication 4 September 2000)

The surface modification of low density polyethylene (LDPE) sheet was carried out by corona discharge treatment under various humidities. The adhesive strength was measured by a peel test for the laminated film composed of LDPE with polyethyleneterephthalate (PET). The adhesive strength became strong with the increase of humidity and reached the maximum. However, it was found that too much humidity would make the adhesive strength weak, and therefore there is the most appropriate humidity. The adhesive strength reached over 1000 N/m when both of LDPE and PET were treated under high humidity.

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