PHYSICAL AND OPTICAL PROPERTIES OF IPNS PREPARED BY BISPHENOL A EPOXIDE-ACRYLATE HYBRID MONOMERS

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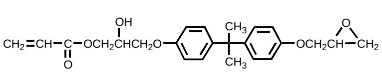
Abstract

Interpenetrating polymer networks (IPNs) were prepared by photo and thermal polymerizations of diacrylate, diepoxide and hybrid monomers, in which the functional groups in each monomer were linked by bisphenol A hard segment. Dynamic mechanical analysis, tensile test, hardness analysis and visible spectrometry were performed to evaluate the properties of the IPNs and their precursors. The IPNs obtained, containing a small amount of diepoxide, indicated the highest mechanical properties at a ratio of hybrid/diacrylate of around 1:2. This composition also agreed with the composition showing the highest surface hardness and transparency.

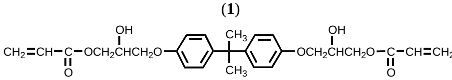
Overview

Copolymer, polymer blend, and interpenetrating polymer network (IPN) have been interested in connection with their applications including adhesives, nano-composites, coatings, and printing inks since they can include at least two diverse characteristic chemical units in materials and represent cooperative specificity. Among such a material, IPN materials containing epoxy and acrylate components, in particular, have been expected to represent unique physical properties, i.e. the IPNs can be expected to have both epoxy characteristics including strong adhesiveness and heat-stability and acrylate characteristics including flexibility and easiness of processing. Thus, so far various types of IPNs have been synthesized using the monomers including diacrylate, dimethacrylate, and diepoxide of bisphenol, phthalic acid ester, and urethane types, respectively. Unfortunately, however, synthesis of the IPN using epoxide-acrylate hybrid monomer and the characteristics of its IPN have not yet been studied up to now.

In the present study, we prepare IPNs by photo and thermal polymerizations of monomer mixtures containing hybride (1), diacrylate (2), and diepoxide (3) linked by bisphenol A hard segment and diluent (4) as shown belows, and will report synergistic effect of the mixtures on the IPN preparation.



(1)



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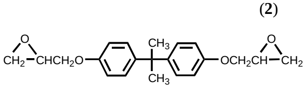

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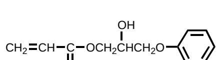

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Preparation & composition of monomers

Table 1.
Preparation of monomers

Monomer code	Feed composition (g) 3[a]	Acrylic acid[a]	TEBAC[b] (g)	Yield (%)
2	173 (1.0)	86.4 (1.2)	1.03	98
M9	173 (1.0)	64.8 (0.9)	0.95	95
M8	173 (1.0)	57.6 (0.8)	0.85	95
M7	173 (1.0)	50.4 (0.7)	0.74	98
M6	173 (1.0)	43.2 (0.6)	0.64	98
M5	173 (1.0)	36.0 (0.5)	0.53	98
M4	173 (1.0)	28.8 (0.4)	0.43	98

[a] The number in the parentheses represents a molar equivalent.
[b] TEBAC denotes a triethylbenzylammonium chloride used as a curing reagent.

Table 2.
Composition and epoxy equivalent of monomers

Monomer code	Monomer composition (mol%)[a] 1	2	3	Epoxy equivalent[b] Observed		Calcd
2	0	100	0	0	0	0
M9	19.7	80.3	0	2408	2385	2384
M8	32.3	64.2	3.5	1173	1160	1156
M7	38.5	51.5	10.0	753	755	747
M6	47.3	37.2	15.5	568	546	538
M5	50.2	26.6	23.2	420	429	419
M4	53.0	12.4	34.6	330	324	319
3	0	0	100	173	173	170

[a] Monomer composition was determined by HPLC under the condition shown in the text.
[b] The front and rear numbers in the observed values are determined by titration and HPLC experiments respectively, and the calculated EE values were estimsted on the hypothesis of a complete acrylation using pure reactants.

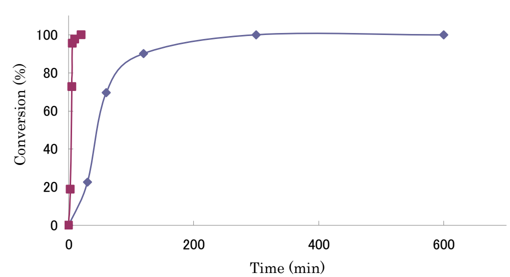


Fig.1. Time-conversion curves for epoxy polymerization of pre-IPN(M4) with 2-ethyl-4-methylimidazole by (A) microwave irradiation and (B) heating in an oven at 100oC. Polymerization condition: [imidazole]=1.0 and 0.5 wt% with respect to the total amount of M4 and 4.

Optical properties

Table 3.
Transmittance of IPNs

Sample	Curing method	Curing agent (wt-%)	Transmittance (%) 470nm	600nm
IPN(2)	Heating	1.0	97.6	98.2
IPN(M9)	Heating	1.0	92.8	94.6
IPN(M8)	Heating	1.0	94.8	96.9
IPN(M7)	Heating	1.0	92.3	93.7
IPN(M6)	Heating	1.0	91.3	91.8
IPN(M5)	Heating	0.5	90.5	91.4
IPN(M5)	Heating	1.0	88.1	89.9
IPN(M5)	Microwave	0.5	74.2	77.6
IPN(M5)	Microwave	1.0	72.6	76.4
IPN(M4)	Heating	1.0	82.8	87.5
IPN(3)	Heating	1.0	73.1	83.8

Physical properties

Table 4.
Mechanical properties for IPNs

Sample	Stress at break (MPa)	Young's modulus (MPa)
IPN(2)	70.6	1472
IPN(M9)	82.1	1717
IPN(M8)	85.3	1748
IPN(M7)	78.4	1680
IPN(M6)	75.0	1658
IPN(M5)	69.5	1646
IPN(M4)	69.2	1640
IPN(3)	52.8	1265

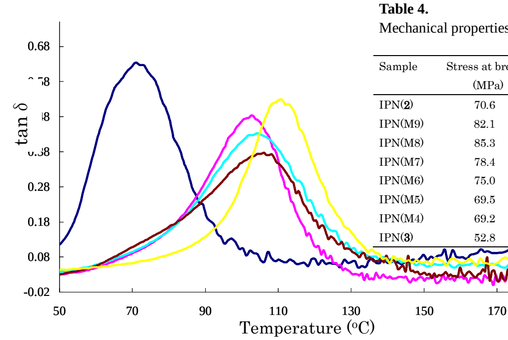
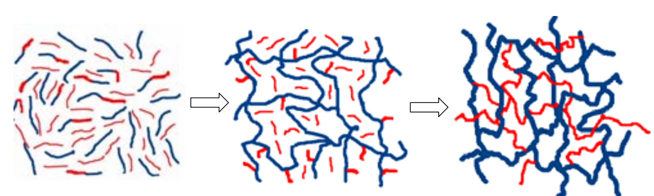


Fig. 2. Temperature dependence of tan δ for INP(2), IPN(M8), IPN(M6), IPN(M4), and IPN(3) (from left to right).



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