

# Modified fracture toughness of Epoxy by blending KURARITY™

KURARITY business promotion dept.  
Elastomer Division

***kuraray***

# Advantages of KURARITY™ as modifier of fracture toughness of epoxy



KURARITY™ as “MAM” structure  
-> Made by controlled living anionic polymerization

## Features of “MAM”

PMMA segment

PnBA segment

Micro phase separation  
(Due to block copolymer)

## Advantages as modifier

Excellent compatibility to epoxy

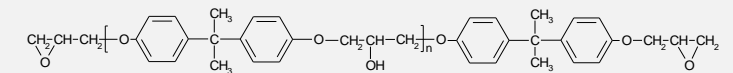
Good fracture toughness

Excellent dispersion contribute to keep flexural modulus and Tg

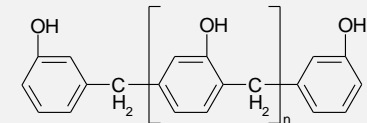
# Test method

- KURARITY™ was mixed with DGEBA\*<sup>1</sup> and the mixture was heated while being stirred in an oil bath at 160-200 deg.C for 30 min to dissolve the KURARITY™ in DGEBA.
- After the mixture was cooled to below 100 deg.C, curing agents\*<sup>2</sup>, \*<sup>3</sup>, and a small amount of a catalyst in necessary\*<sup>4</sup>, were added to the mixture and degassed using a planetary centrifugal vacuum mixer
- The liquid epoxy polymer blends were cast into pre-heated molds
- The blends were then cured in the oven at 120 deg.C for 2 hrs, then 150 deg.C for 2hrs

**\*1 Di-Glycidyl Ether of Bisphenol A (DGEBA)**  
(Epoxy equivalent weight: 189g/eq.)



**\*2 Phenol Novolac (PN) as a curing agent**



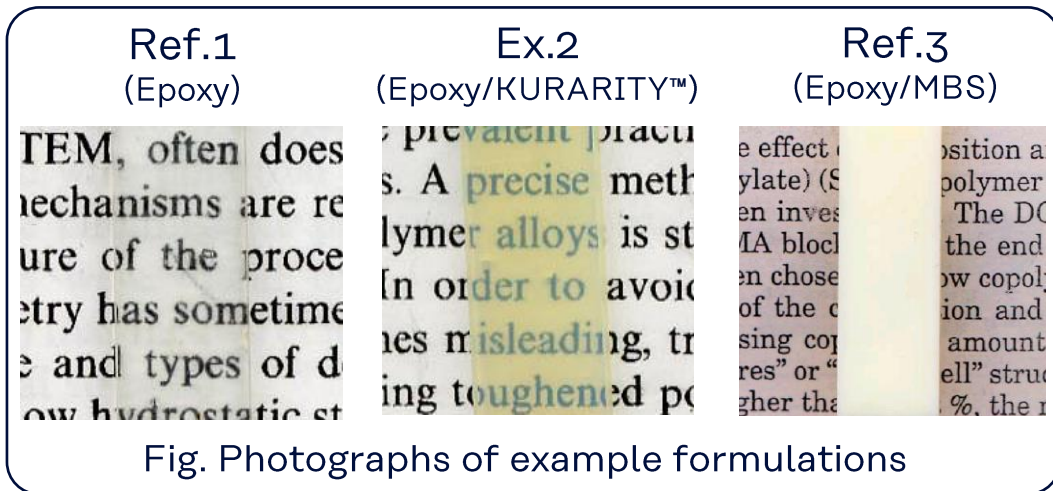
**\*3 4,4'-methylenebis (3-chloro-2,6-diethyl aniline)(MCDEA) as a curing agent**

**\*4 Triphenylphosphine (TPP) as a curing catalyst for PN**  
(5 parts TPP in 100 parts of DGEBA)

# 1. DGEBA/PN/TPP curing system

# Typical properties (DGEBA/PN/TPP/KURARITY™ system)

		Ref.1	Ex.1	Ex.2	Ref.2	Ref.3		
Epoxy	Di-glycidyl ether of bisphenol A (DGEBA)	100	90	80	90	80		
Modifier	KURARITY™ LA2250		10	20				
	MBS (PARALOID™ EXL-2655)				10	20		
Items	Methods	Conditions	Units	Properties				
Fracture toughness ( $K_{IC}$ )	ASTM D 5045-91	---	MPa m <sup>1/2</sup>	0.64	2.5	2.4	2.1	2.0
Flexural modulus	ISO 178	---	GPa	3.5	2.8	2.5	2.8	2.0
Adhesion strength	ISO 9664	To Al	N/25 mm	5.7	31	47	---	---
Lap shear strength	ISO 4587	To SUS	MPa	17	21	30	---	---

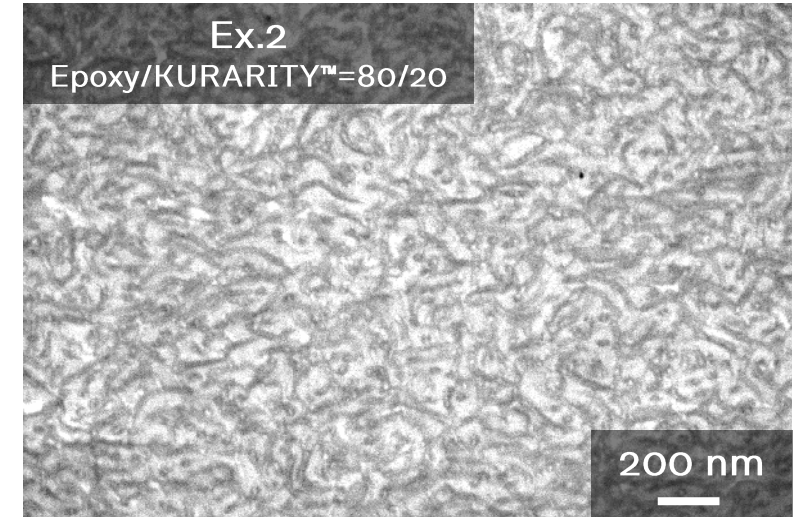
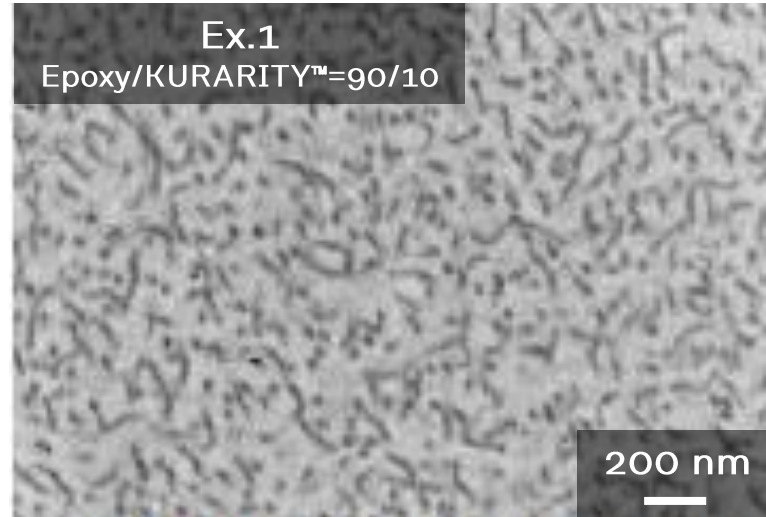


- By adding KURARITY™ to epoxy, fracture toughness, adhesion strength and lap shear strength can be improved. (Ex.1, 2)
- Comparing to MBS addition, KURARITY™ addition maintained better transparency and balance between fracture toughness and flexural modulus.

# TEM observation

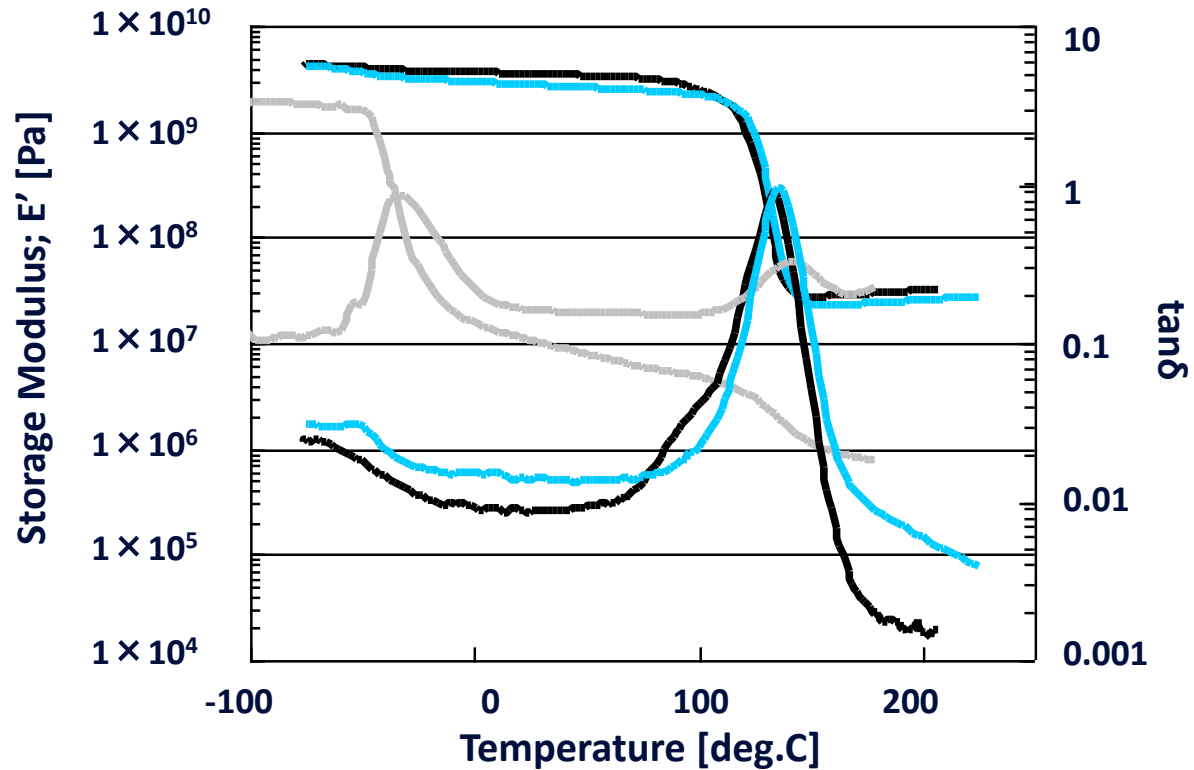
Matrix (Gray part):  
DGEBA+PN + PMMA  
(Miscible)

Domain (Black part):  
PnBA  
(Immiscible to DGEBA+PN)

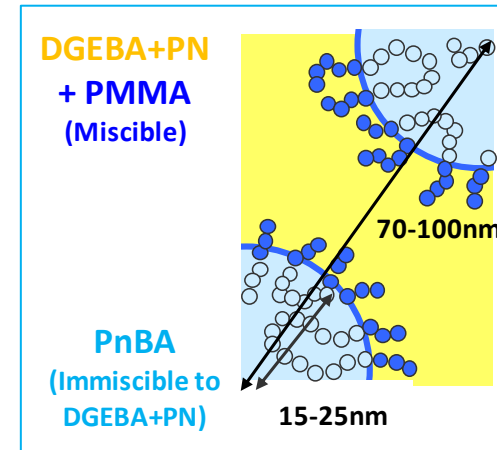


- By adding KURARITY™ to epoxy, KURARITY™ can be dispersed as cylinder about 20-30 nm diameter
- PnBA content in KURARITY™ grade would be affect to the morphology.

# Dynamic viscoelastic behavior



— Ref.1 Epoxy  
 — Ex.2 Epoxy/KURARITY™=90/10  
 — KURARITY™



- Thanks to excellent dispersion of KURARITY™ in epoxy, Ex.2 maintained similar storage modulus between -30 to 120 deg.C compared to Ref.1 (epoxy).
- Tg of epoxy was not decreased drastically by adding KURARITY™

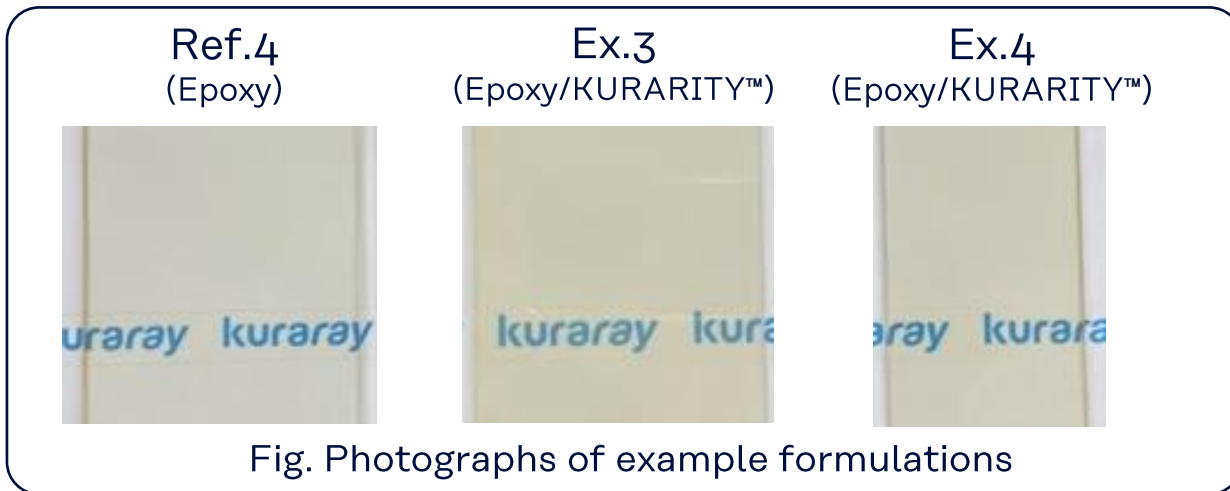
2.DGEB A/MCDEA

curing system



# Typical properties (DGEBA/MCDEA/KURARITY™ system)

		Ref.4	Ex.3	Ex.4		
Epoxy	Di-glycidyl ether of bisphenol A (DGEBA)	100	90	80		
Modifier	KURARITY™ LA2250		10	20		
Items	Methods	Conditions	Units	Properties		
Fracture toughness ( $K_{IC}$ )	ASTM D 5045-91	---	MPa m <sup>1/2</sup>	0.57	2.3	1.3
Flexural modulus	ISO 178	---	GPa	3.0	2.6	2.1
Adhesion strength	ISO 9664	To Al	N/25 mm	1.7	28	2.9
Lap shear strength	ISO 4587	To SUS	Mpa	21	36	24



-By adding KURARITY™ to epoxy cured by MCDEA system, fracture toughness, adhesion strength and lap shear strength can be improved. (Ex.3, 4)

**Kuraray Co., Ltd.**  
Elastomer Division  
Tokiwabashi Tower  
2-6-4, Otemachi  
Chiyoda-ku, Tokyo, 100-0004, Japan

✉ [elastomer@kuraray.com](mailto:elastomer@kuraray.com)

→ [www.kuraray.com](http://www.kuraray.com)

→ [www.elastomer.kuraray.com](http://www.elastomer.kuraray.com)

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