

STRUCTURE AND PROPERTIES OF LIQUID CRYSTALLINE THERMOSETTING POLYIMIDES

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Introduction

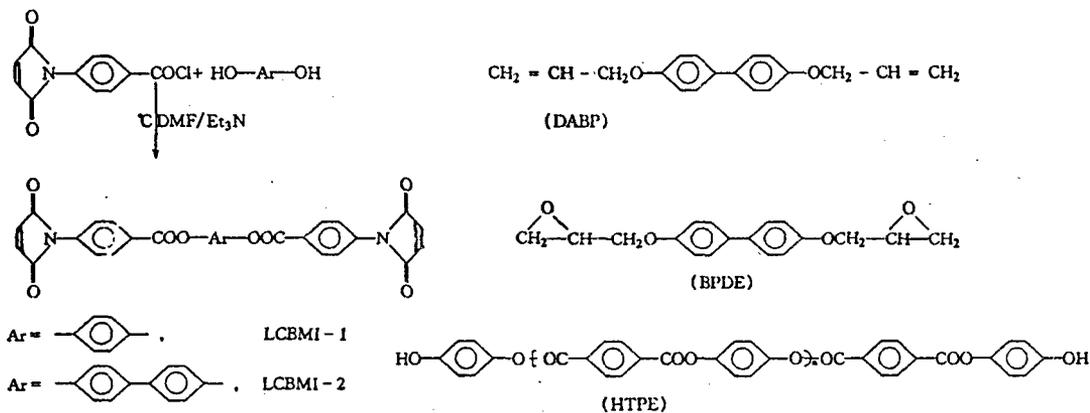
Liquid crystal thermosets (LCT's) would exhibit desirable properties in both the uniaxial and transverse directions and should be good candidates for advanced composites, self-reinforced composites, low-dielectric materials in electronic packaging and nonlinear optical materials applications, etc^[1]. Recently there has been a growing interest in the preparation and characterization of LCT's^[2-4] to prepare such networks has resulted in some these networks having a liquid crystal molecular organization. The main impetus for this research has been the growing interest in both the theoretical aspects and the technical applications of LCT's.

Based on the concept of LCT's^[5], the preparation of LCT polyimides containing bismaleimide segments show in following, (1) Synthesizing liquid crystal bismaleimides containing aromatic ester bonds or amide bonds, then extended by aromatic diamine, such as diaminodiphenyl sulphone (DDS), diaminodiphenyl methane (MDA) and diaminodiphenyl ether (ODA). (2) Synthesizing liquid crystal copolymerizable monomers with non liquid crystal bismaleimide (BMI), such as 4,4' - diallyl oxybiphenylene (DABP), bisphenol diglycidyl ether (BPDE) and hydroxy terminated liquid crystal polyester (HTPE)^[6-8]. (3) Using liquid crystal bismaleimide extended by liquid crystal copolymerizable monomer, such as DABP and BPDE. This work has focused on the investigations for structure and properties of liquid crystal polyimides containing bismaleimide segments.

Results and Discussion

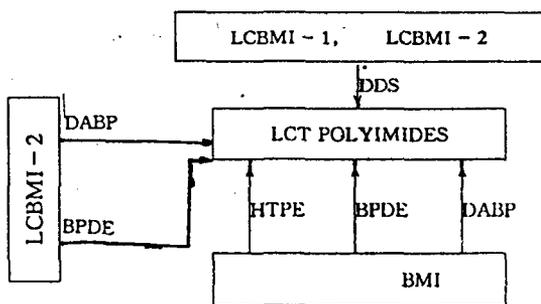
The synthesis of liquid crystal bismaleimide containing aromatic ester bonds outlined in scheme I. The structure of liquid crystal copolymerizable monomers showed in scheme II. Synthesis and characterizations of these monomers were described in previously work^[6-8]. The technical approaches of LCT polyimides are

shown in scheme III.



Scheme I Synthesis of liquid crystal bismaleimide

scheme II Structure of liquid crystal copolymerizable monomer



Scheme III Approaches to prepare liquid crystal polyimide containing bismaleimide

Table 1 listed the thermal properties and thermal transitions of monomers and some LCT polyimides.

Table 1 The thermal properties of monomers and polyimides.

monomer or polyimide	LC phase °C	T _{curing} °C	t _{gel} (at170°C) min
LCBMI-1	250~298	290	
LCBMI-2	300~330	342	
DABP	108~174	288	
BPDE	142~180		
HTPE	172~248		
LCBMI-1/DDS(3.7/1)	150~200	250	26.38
LCBMI-2/DDS(3.7/1)	170~220	250	62.50
BMI/DABP(50/50)	147	227	123.15
BMI/HTPE(62/38)	148~180	250	18.50
BMI/BPDE(1/1)	89~167	184	32.64
LCBMI-2/DABP(50/50)	95~145	245	119.40

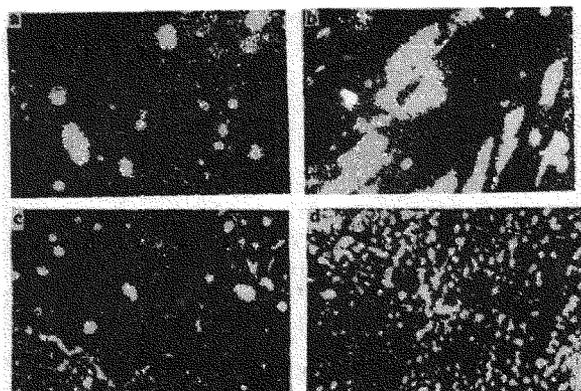
The cured LCT polyimides were obtained from curable polyimides precured at liquid crystal state and fully cured at 200°C under 200Mpa for 3hrs. The conditions and properties listed in table 2 .

Table 2 Processed conditions and properties of LCT polyimides containing bismaleimide segments

Sample	polyimide	precured conditions			T _g (°C)	T _s * (°C)	flexible strength (MPa)
		time (min)	temp (°C)	force (MPa)			
1	LCBMI-1/DDS	30	150	50	286	200	40.25
2	(3.7/1)	60	150	50	299	200	66.13
3	LCBMI-2/DDS	0	0	0	306	184	25.33
4	(3.7/1)	30	150	50	312	196	41.64
5		60	150	50	337	203	76.20

T_s* — heat resistance index by TG.

These LCT polyimides would exhibit good liquid crystal behavior and thermal curable properties. Liquid crystal textures retained in crosslinked networks (seen in figure 1). Good self-reinforced characters were obtained in the fracture surface (seen in figure 2).



a: EPBMI-1 at 120°C b: EPBMI-1 at 180°C
c: EPBMI-2 at 160°C d: EPBMI-2 at 200°C

Figure 1 Polarized optical micrograph of LCT polyimides

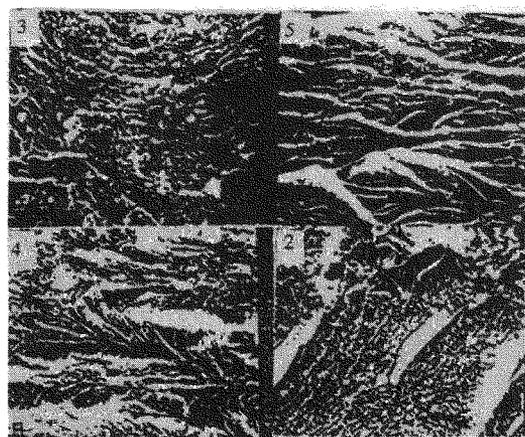


Figure 2 Fracture Surface of LCT polyimide

Fractal characterizations of LCT polyimides were studied in this work . The flexible strength of LCT polyimides materials increased linearly with the rise of fractal dimension value by the fracture features which existed self-similarity^[9,10],

seen in figure 3 and figure 4.

The BMI/HTPE(62/28) glass fiber composite was studied, 708MPa flexible strength, $5.46 \times 10^{13} \Omega$ surface electric resistance and $2.40 \times 10^{13} \Omega$ volume electric resistance were obtained.

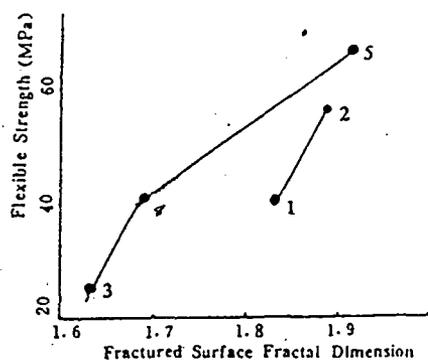


Figure 3 Relations between flexible strength and its fracture surface fractal dimension Value

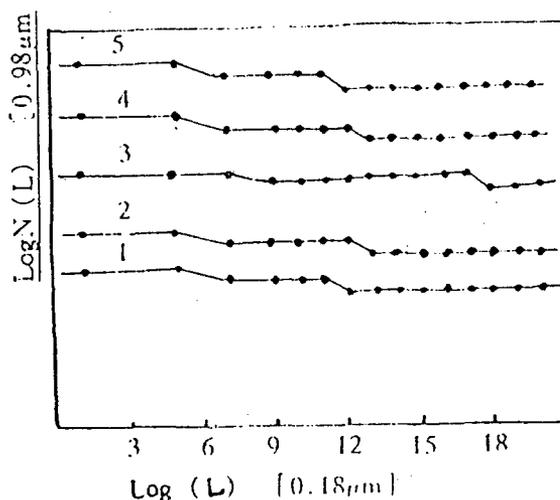


Figure 4 Fractal characterizations

Acknowledgment

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References

- [1] Barclay G. G., et al, *Macromolecules*, 1992, 25, 2947
- [2] Xiaobo Liu, et al, *J. Functinal Materials*, 1993, 24(6), 493
- [3] Barclay G. G., et al, *J. Polym. Sci., Polym. Chem. Ed.*, 1992, 185, 163
- [4] Xiaobo Liu, et al, *Polymeric Materials Science & Engineering*, 1993, 4, 124
- [5] Xiaobo Liu, Ph D Thesis, Sichuan Union University, 1995
- [6] Xiaobo Liu, et al, *Thermosets*, 1994, 3, 17
- [7] Xiaobo Liu, et al, *Engineering Plastics Applications*, 1994, 22, 3
- [8] Xiaobo Liu, et al, *Polymeric Materials Science & Engineering*, 1995, 1, 112
- [9] Xiaobo Liu, et al, *Polymeric Materials Science & Engineering*, 1995, 5, 63
- [10] Xiaobo Liu, et al, *The 3rd IUMRS International Conference in Asia (Seoul, Korea), Proceeding*, 1995