

CHAPTER 7

MORPHOLOGY AND WATER ABSORPTION BEHAVIOUR

This chapter discusses the morphology and moisture absorption characteristics of the cured epoxy, siliconized epoxy, and bismaleimides (BMI-1, BMI-2, BMI-3 and BMI-4) modified epoxy and siliconized epoxy systems.

7.1 MICROSCOPIC INVESTIGATION

Scanning electron microscope is used to investigate the morphology of matrix systems (Figures 7.1 to 7.3). SEM micrograph of fractured surface of the unmodified epoxy system (Figure 7.1a) reveals smooth, glassy and homogeneous microstructure without any plastic deformation. The fractured surface of the siliconized epoxy resin (Figures 7.1b-7.1d) system reveals the presence of heterogeneous morphology of the fractured surface and the heterogeneity increases with increasing siloxane content. Another interesting observation is that the siloxane molecule (HTPDMS) did not rise up to the top layer of the viscous epoxy resin during sample preparation. Instead it spreads over the whole specimen due to the fact that HTPDMS is chemically bonded with epoxy resin through γ -aminopropyltriethoxysilane (crosslinking agent).

The SEM micrograph of the fractured surface of bismaleimides (BMI-1, BMI-2, BMI-3 and BMI-4) modified epoxy system (Figures 7.2a-7.2d) is almost similar to that of unmodified epoxy system (Figure 7.1a). This

indicates that there are no phase domains of the two components and it also suggests that the formation of homogeneous intercrosslinked network, whereas, the fractured surface of the bismaleimides ((BMI-1, BMI-2, BMI-3 and BMI-4) modified siliconized system reveals the presence of heterogeneous morphology and also smooth fracture surface is observed with increasing bismaleimide content (Figures 7.3a-7.3d). This may be due to the brittle behaviour imparted by bismaleimides.

7.2 WATER ABSORPTION

Presence of moisture in the matrix material affects the electrical insulation characteristics and the mechanical properties. Water absorption characteristic of the pure epoxy system, siliconized epoxy systems, and bismaleimides (BMI-1, BMI-2, BMI-3 and BMI-4) modified epoxy and siliconized epoxy systems are presented in Table 7.1. The water absorption test was carried out by immersing the specimen of appropriate dimension in distilled water at 30°C for 24 hours.

7.2.1 Effect of siloxane

The siloxane incorporation into epoxy system decreases the water absorption behaviour with increasing its concentration. For example, the percentage water uptake for unmodified epoxy systems is 0.1201, whereas for 5%, 10% and 15% siloxane incorporation the percentage water uptake is 0.1152, 0.1105 and 0.1032 respectively. The decrease in percentage water uptake for siloxane incorporated system is due to the inherent hydrophobic nature of $-\text{Si-O-Si}-$ linkage (Figure 7.4)

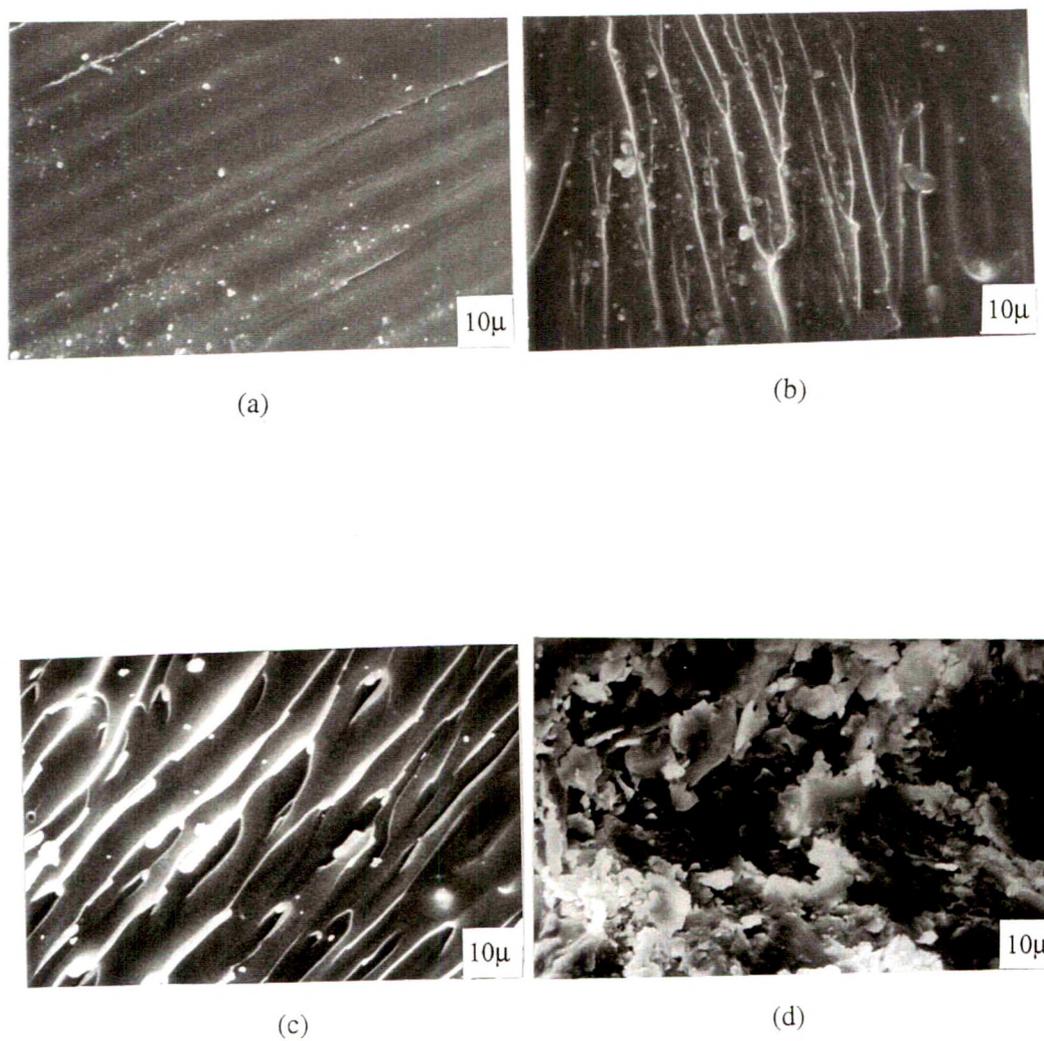


Figure 7.1 SEM micrographs of (a) unmodified epoxy, (b) 5%, (c) 10% and (d) 15% siliconized epoxy systems.

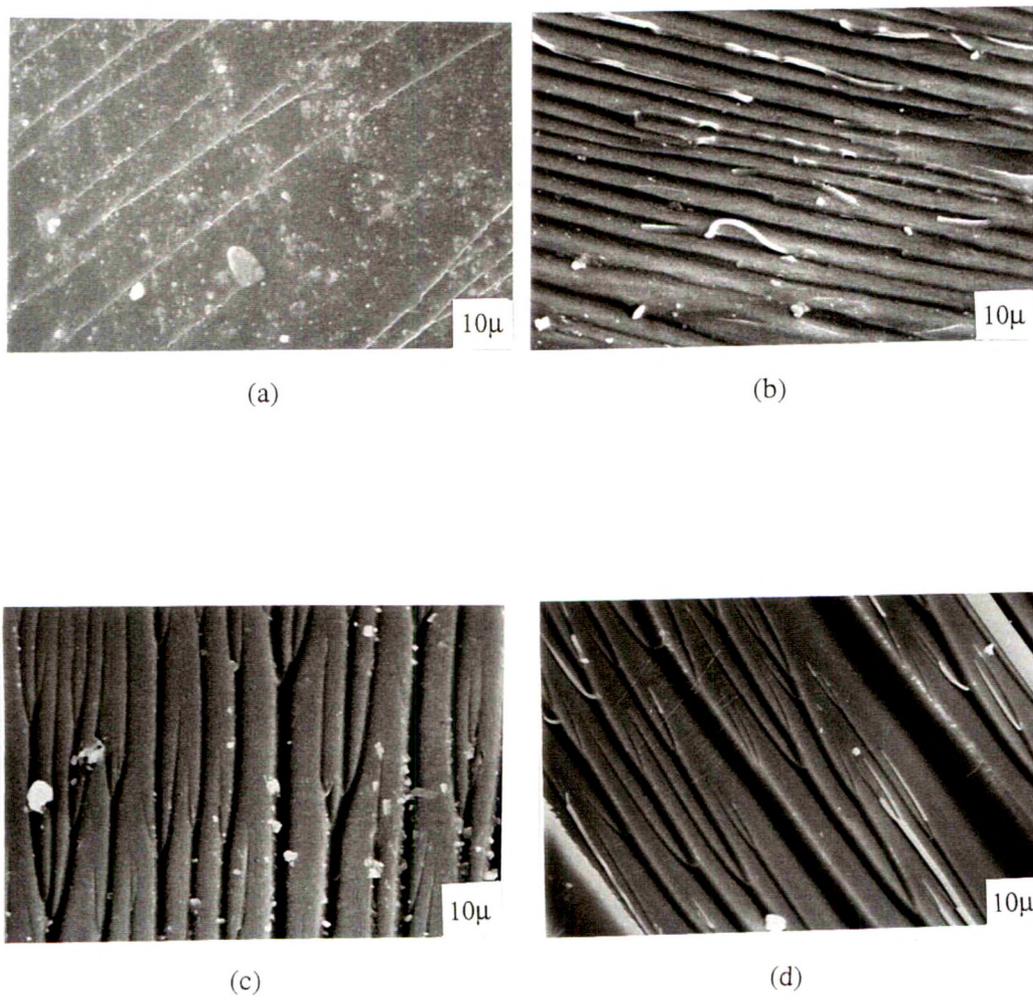


Figure 7.2 SEM micrographs of (a) 10% BMI-1, (b) 10% BMI-2, (c) 10% BMI-3 and (d) 10% BMI-4 modified epoxy systems

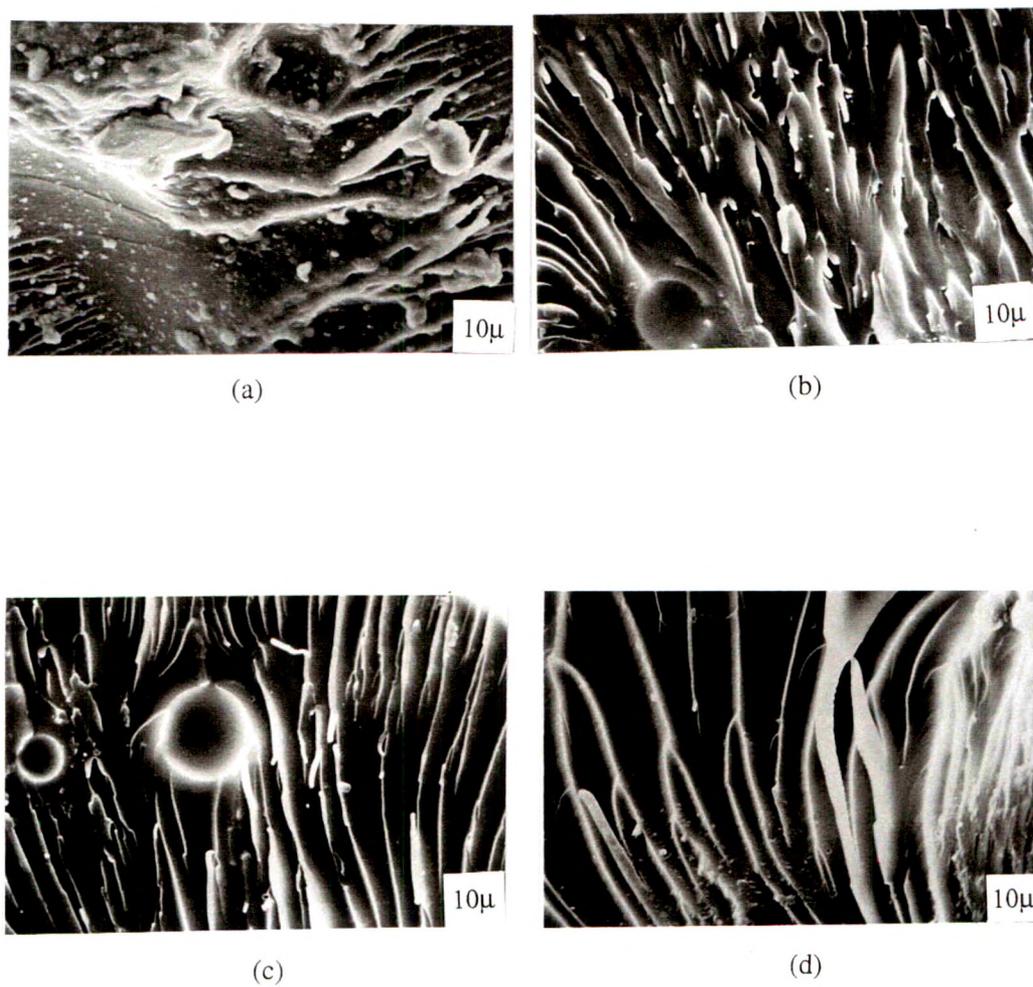


Figure 7.3 SEM micrographs of (a) 10% BMI-1, (b) 10% BMI-2, (c) 10% BMI-3 and (d) 10% BMI-4 modified siliconized (10%) epoxy systems

7.2.2 Effect of bismaleimides

The inclusion of bismaleimides BMI-1, BMI-2, BMI-3 and BMI-4 into epoxy and siliconized epoxy systems hardly affects the percentage water uptake. This may be due to the fact that more effective network is formed when increasing bismaleimides concentration, which in turn increase the crosslinking density and rigidity. No appreciable change in water absorption behaviour is observed among the bismaleimides (Figures 7.5-7.6).

However, the percentage water uptake in the bismaleimides modified siliconized epoxy systems are slightly lower than that of bismaleimides modified epoxy and siloxane modified epoxy systems. This may be due to the combined effect of bismaleimides and siloxane, since both are having negligible tendency to absorb moisture.

Table 7.1 Water absorption behaviour of epoxy, siliconized epoxy, and bismaleimides modified epoxy and siliconized epoxy systems

Percentage water absorption				
Percentage of siloxane content in epoxy system	0%	5%	10%	15%
	0.1201	0.1152	0.1105	0.1032
Percentage of BMI content in epoxy system	0%	5%	10%	15%
BMI-1	0.1201	0.0816	0.0786	0.0697
BMI-2	0.1201	0.0810	0.0692	0.0631
BMI-3	0.1201	0.0778	0.0742	0.0611
BMI-4	0.1201	0.0793	0.0751	0.0656
Percentage of BMI content in 10% siliconized epoxy system	0%	5%	10%	15%
BMI-1	0.1105	0.0711	0.0646	0.0566
BMI-2	0.1105	0.0655	0.0583	0.0526
BMI-3	0.1105	0.0634	0.0546	0.0511
BMI-4	0.1105	0.0656	0.0621	0.0539

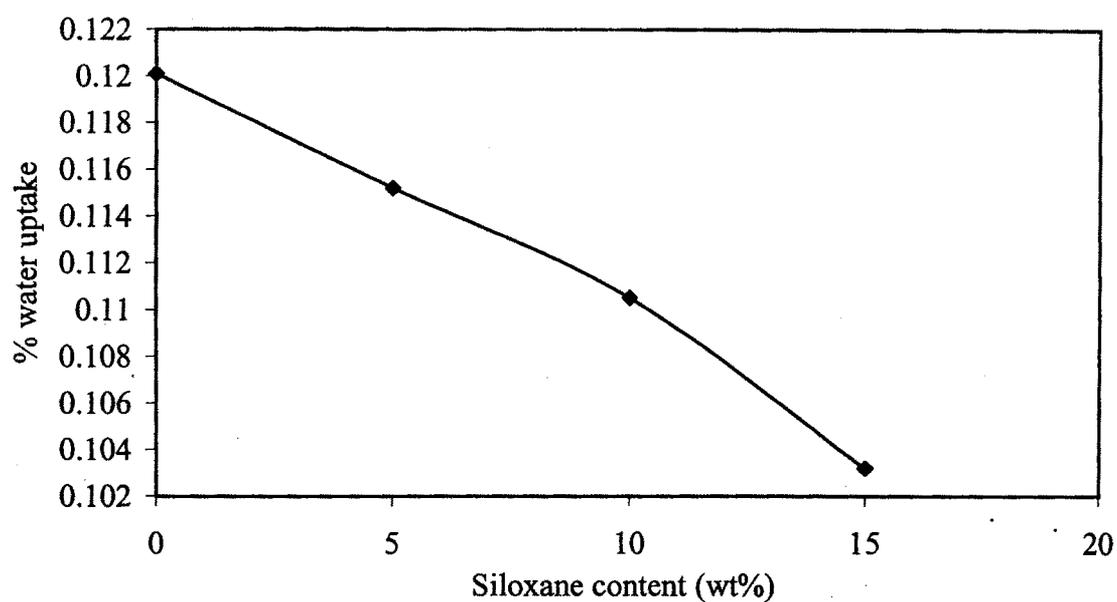


Figure 7.4 Effect of siloxane content on water absorption of epoxy system

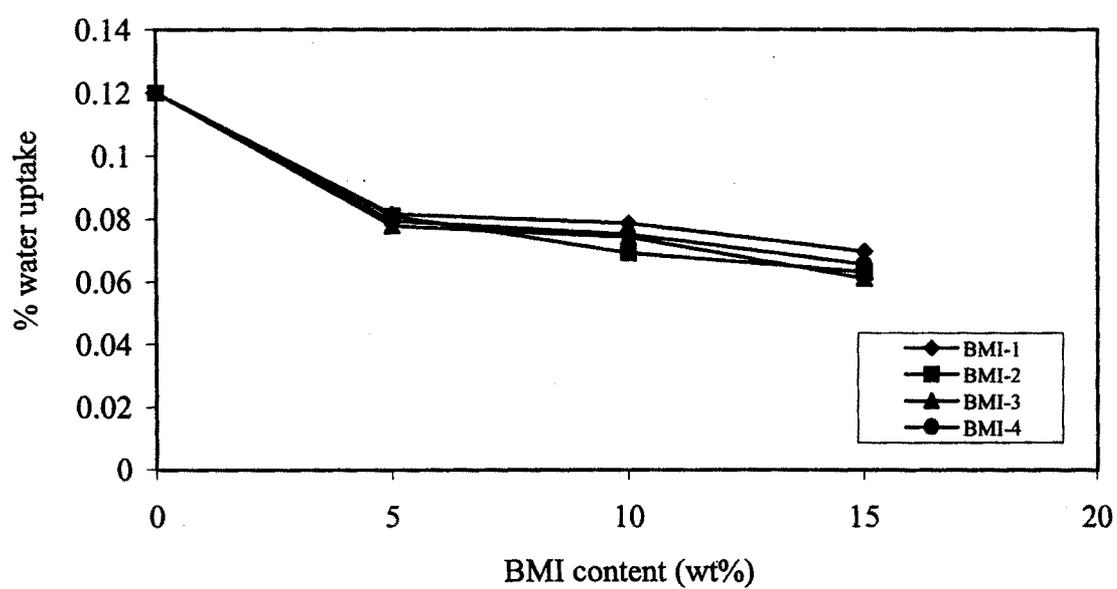


Figure 7.5 Effect of bismaleimides (BMI-1, BMI-2, BMI-3 and BMI-4) content on water absorption of epoxy system

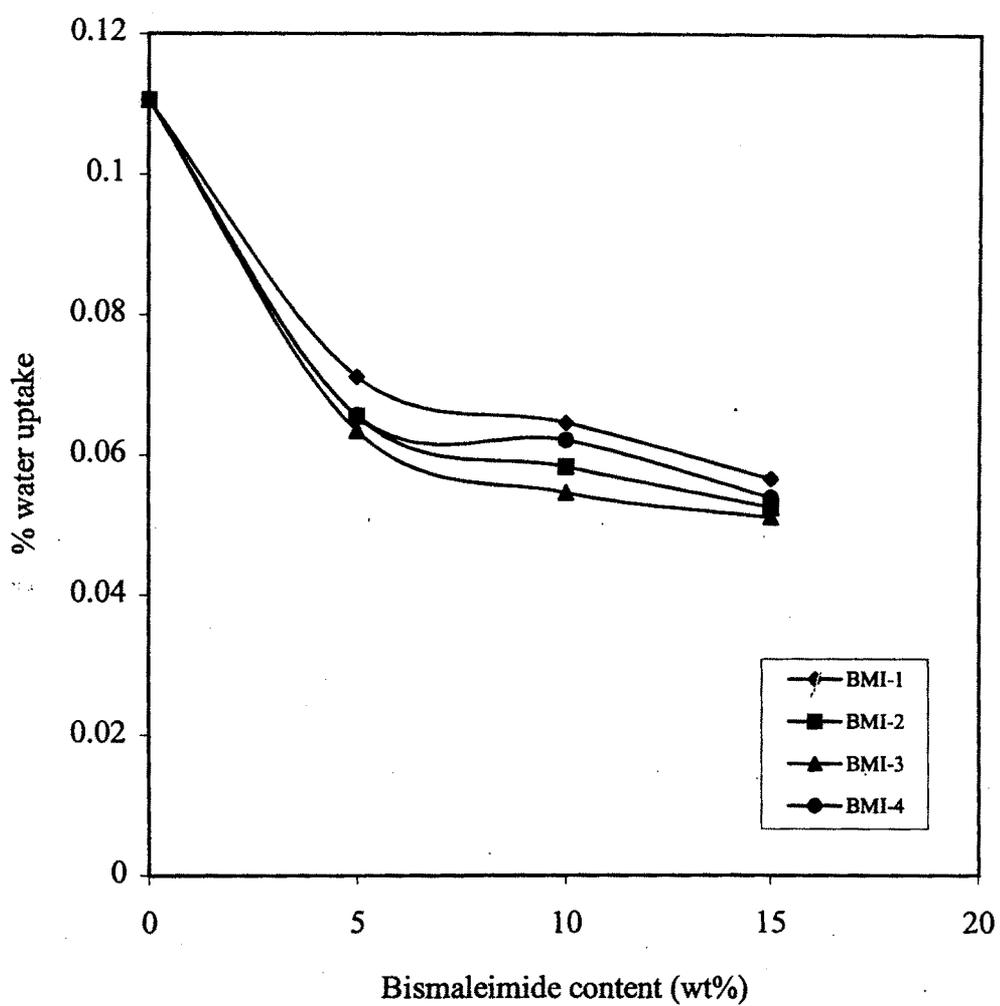


Figure 7.6 Effect of bismaleimides content on water absorption of 10% siliconized epoxy system