CHAPTER IV
RESULT AND DISCUSSION

4.1 Characterization of poly(S/EGDMA) porous foam

4.1.1 Morphology of poly(S/EGDMA) porous foam

Poly(styrene/ethylene glycol dimethacrylate) polyHIPE porous foams were successfully prepared via the high internal phase emulsion polymerization technique. SEM images of the poly(S/EGDMA) polyHIPE porous foams with magnification ×400 were shown in Figure 4.1- 4.5. Phase morphologies of the poly(S/EGDMA) polyHIPE porous foams show both open and closed cellular structures due to the ratio of monomer. Only the open cellular structures have interconnected pore in which each pore is connected to some or all of its neighbors.

The average pore diameter of the polyHIPEs found to increase with increasing the volume of EGDMA as a cross-linking reagent. The openness of polyHIPE porous structure decreases with increasing EGDMA content.

Poly(S/EGDMA) porous foam having S:EGDMA; 90:10 ratio by volume has opened cell and highly interconnected structure which pores are connected to other pores. This porous foam has average pore size about 79.74 μm.

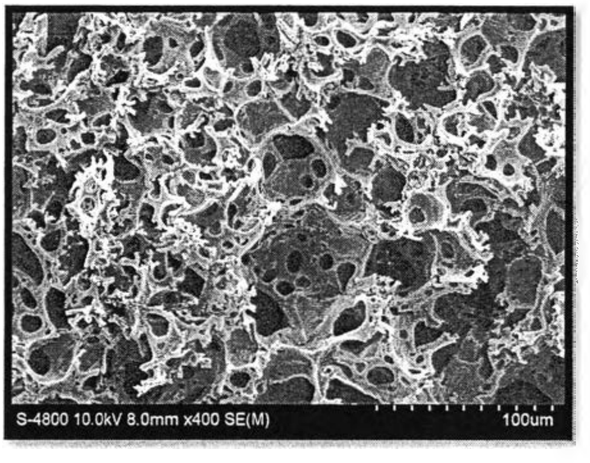

Figure 4.1 Morphology of poly(S/EGDMA) polyHIPE which has S:EGDMA 90:10 ratio by volume.

Poly(S/EGDMA) porous foam having S:EGDMA; 80:20 ratio by volume has polyHIPE opened cell structures. A porous foam has average pore size about 86.98 μm.

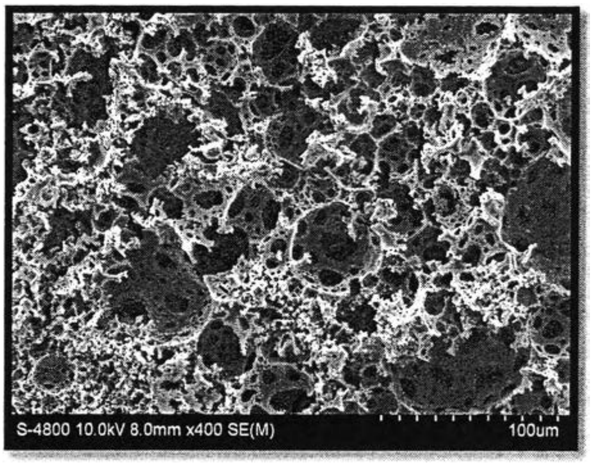

Figure 4.2 Morphology of poly(S/EGDMA) polyHIPE which has S:EGDMA 80:20 ratio by volume.

Poly(S/EGDMA) porous foam having S:EGDMA; 70:30 ratio by volume has the highest interconnection level and opened cell structures. This porous foam has average pore size about 110.49 μm.

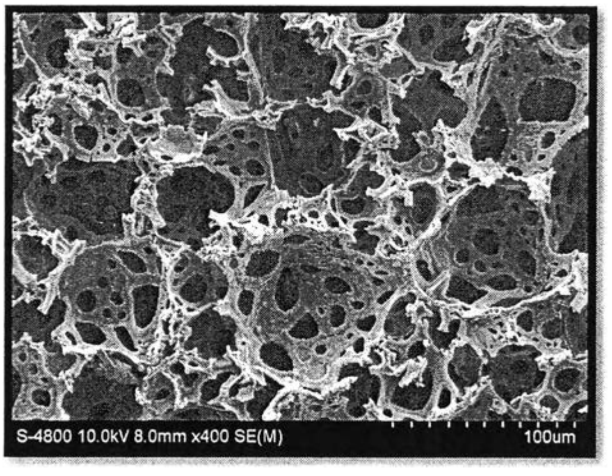

Figure 4.3 Morphology of poly(S/EGDMA) polyHIPE which has S:EGDMA 70:30 ratio by volume.

Poly(S/EGDMA) porous foam having S:EGDMA; 60:40 ratio by volume has both open and closed cellular structures. This porous foam has average pore size about 118.80 μm.

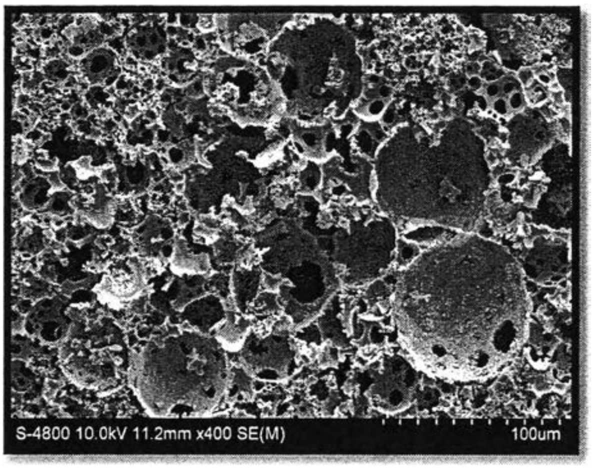

Figure 4.4 Morphology of poly(S/EGDMA) polyHIPE which has S:EGDMA 60:40 ratio by volume.

Poly(S/EGDMA) porous foam having S:EGDMA; 50:50 ratio by volume has both open and closed cellular structures. This porous foam has average pore size about 120.66 μm.

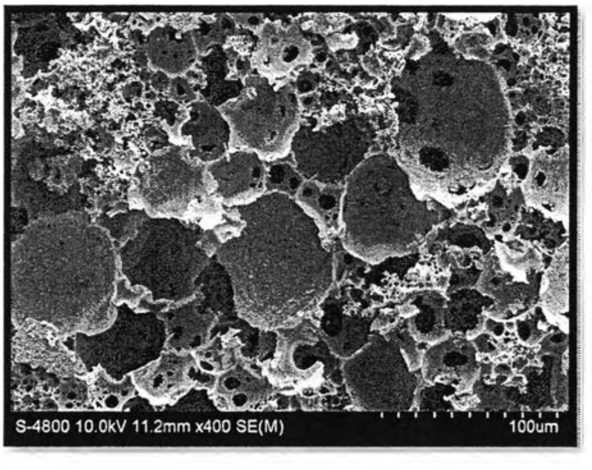

Figure 4.5 Morphology of poly(S/EGDMA) polyHIPE which has S:EGDMA 50:50 ratio by volume.

4.1.2. Properties of poly(S/EGDMA) porous foam

The changes in surface properties of the polyHIPE porous foams were characterized by contact angle measurement. The hydrophilicity of polyHIPE porous foams increases with increasing the EGDMA content as observed by a decrease in a contact angle degree (Table6.1). BET surface area decreases with increasing pore size. BET surface areas, pore size and contact angle of polyHIPE were shown in Table 4.1. Mechnical properties of polyHIPE porous foams are shown in Table 4.2.

Table 4.1 The table shows physical properties which are average pore size, BET surface area and contact angle of poly(S/EGDMA) polyHIPE

S: EGDMA ratio	Pore size (μm)	Surface area (m^2g^{-1})	Contact angle (Θ)
90:10	79.74	40.60	141.13
80:20	86.98	32.54	129.33
70:30	110.49	28.72	111.33
60:40	118.80	24.40	104.23
50:50	120.66	19.80	98.63

Poly(S/EGDMA) porous foam having S:EGDMA; 70:30 ratio by volume is the suitable condition to process the poly(S/EGDMA) scaffold. Since, it has the highest porosity and high interconnectivity which are the characteristics of scaffolds. Scaffolds must have high porosity and high interconnectivity to increase the area for cell attachment, facilitate cell growth, and transport the nutrients or waste to the cells. Poly(S/EGDMA) porous foam having S:EGDMA; 70:30 ratio by volume also has the most opened cell structures with three dimensional structures. Thus, this porous foam is highly permeable and exhibits a relatively low density. Moreover, the pore size of poly(S/EGDMA) porous foam having S:EGDMA; 70:30 ratio is the optimal size that required for the growth of osteoblast. Therefore; this poly(S/EGDMA) porous foam can fulfill the requirements of scaffold for tissue engineering application.

Table 4.2 The table shows mechanical properties of poly(S/EGDMA) porous foams

S: EGDMA ratio	Young's modulus (MPa)	Compressive strength (MPa)
90:10	2.56 ± 0.05	0.54 ± 0.01
80:20	4.30 ± 0.07	0.67 ± 0.08
70:30	1.25 ± 0.11	0.12 ± 0.01
60:40	2.43 ± 0.17	0.30 ± 0.03
50:50	3.19 ± 0.17	0.26 ± 0.01

The mechanical properties of the polyHIPE porous foams were evaluated through measurements of their Young's modulus and compressive strength. In table6.2 shows that the Young's modulus and compressive strength is relatively independent of crosslink content (EGDMA). Similar results were obtained by Williams and co-workers (Williams et.al (1988)).

4.2 Characterization of Modified Poly(S/EGDMA) Porous Foam

4.2.1 Morphology of modified poly(S/EGDMA) porous foam

Poly(S/EGDMA) porous foams can be modified with hydroxyapatite by adding hydroxyapatite into the aqueous phase of the emulsion. The effects of incorporating hydroxyapatite on the structure of scaffolds had also been investigated by varying the hydroxyapatite contents. Morphology of polyHIPE porous foams was shown in Figure 4.6 – Figure 4.10.

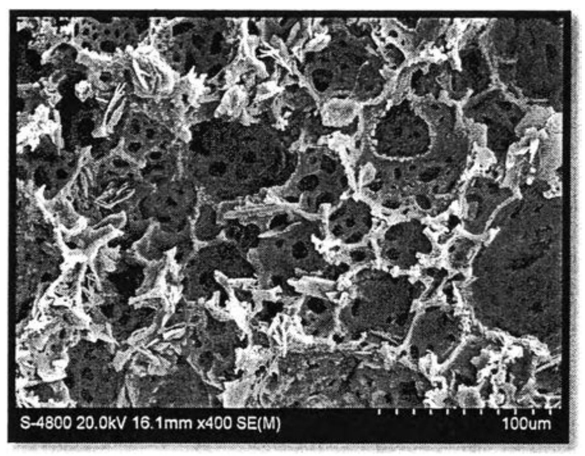

Figure 4.6 Morphology of polyHIPE loaded with hydroxyapatite 0.2 % w/v.

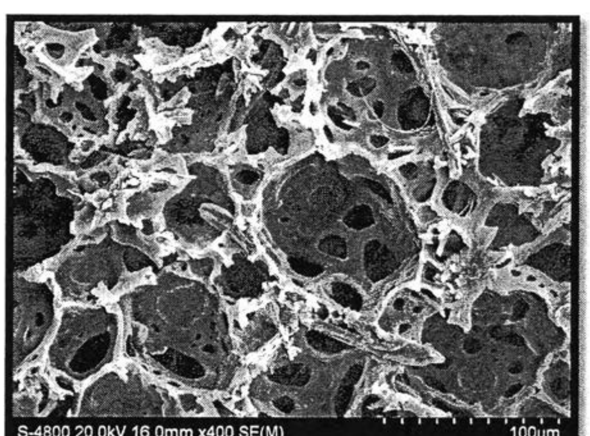

Figure 4.7 Morphology of polyHIPE loaded with hydroxyapatite 0.4 % w/v.

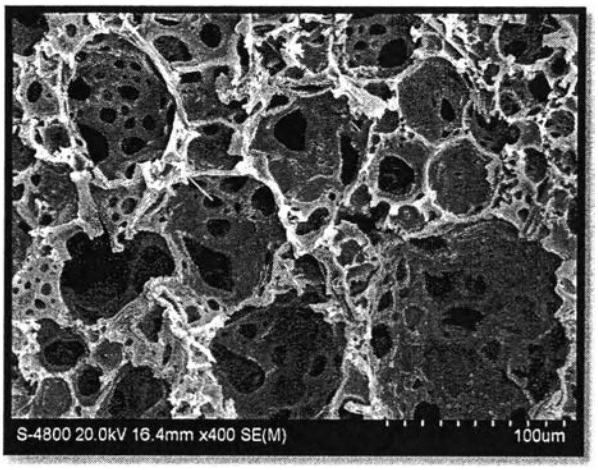

Figure 4.8 Morphology of polyHIPE loaded with hydroxyapatite 0.6 % w/v.

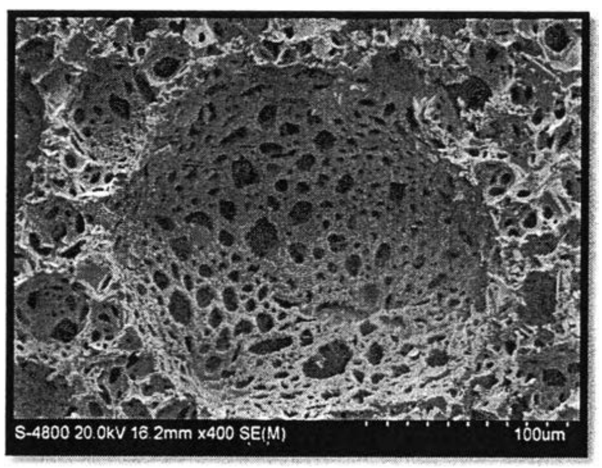

Figure 4.9 Morphology of polyHIPE loaded with hydroxyapatite 0.8 % w/v.

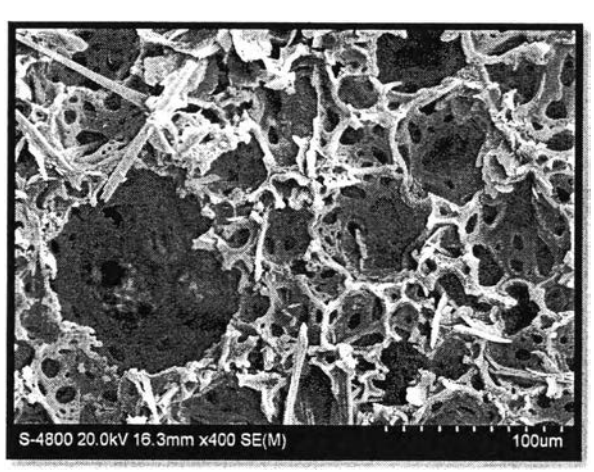

Figure 4.10 Morphology of polyHIPE loaded with hydroxyapatite 1.0 % w/v.

4.2.2. Properties of modified poly(S/EGDMA) porous foam

Loading polyHIPE with hydroxyapatite leads to increasing the hydrophilicity of polyHIPE and average pore sizes. Pore sizes of polyHIPE porous foam increase with increasing hydroxyapatite content until hydroxyapatite is over 0.8% (about 1.0%) , the porosity decreases. Large amounts of hydroxyapatite in the emulsion might cause the agglomeration of the hydroxyapatite particles and block some small interconnected pores, which lowers the pore connectivity and decreases the porosity. Therefore; the optimal condition of polyHIPE porous foams is 0.8% hydroxyapatite which provides the biggest average pore sizes (Table 4.3).

The changes in surface properties of polyHIPE were characterized by contact angle measurement. The hydrophilicity of polyHIPE porous foams increases with increasing the hydroxyapatite content as observed by a decrease in a contact angle degree (Table6.2). BET surface area decreases with increasing pore size. BET surface areas, pore size and contact angle of polyHIPE were shown in Table 4.3. Mechnical properties of modified polyHIPE scaffolds increases with increasing hydroxyapatite content in Table 4.4.

Table 4.3 The table shows physical properties average pore size, BET surface area and contact angle of modified poly(S/EGDMA) porous foam

Hydroxyapatite content (%w/v)	Pore size (μm)	Surface area (m^2g^{-1})	Contact angle (Θ)
0.2	158.46	23.19	104.43
0.4	200.97	19.57	95.17
0.6	275.45	15.10	88.73
0.8	304.35	7.77	78.63
1.0	289.40	12.55	69.47

Table 4.4 The table shows mechanical properties of modified poly(S/EGDMA) porous foam

Hydroxyapatite content (%w/v)	Young's modulus (MPa)	Compressive strength (MPa)
0.2	1.59 ± 0.09	0.20 ± 0.02
0.4	1.87 ± 0.07	0.21 ± 0.01
0.6	2.19 ± 0.08	0.22 ± 0.03
0.8	3.26 ± 0.14	0.40 ± 0.01
1.0	3.84 ± 0.03	0.52 ± 0.01

Young's modulus and compressive strength increase with increasing hydroxyapatite content.