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Synthesis and characteristics of polystyrene nanoparticles and polystyrene membrane

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Abstract

In this paper, polystyrene nanoparticles and polystyrene membrane were successfully synthesized. Polystyrene nanoparticles and their crosslinking were carried out, at 80 ^{0}C temperature by soap-free emulsion polymerization. Polystyrene membrane was synthesized from Polystyrene nanoparticles and its crosslinking were treated with two organic solvents. The product of polystyrene nanoparticles from 399.2 to 621.1nm and Polystyrene nanoparticles shows the best results. The polystyrene membrane shows enhancement product treated with toluene and Tetrahydrofuran. The characterization of Polystyrene nanoparticles and their crosslinking and Membrane fabrications were done by SEM, and TEM.

Keywords: polystyrene nanoparticles, polystyrene crosslinking, membrane and characterization

1. Introduction

In the previous work, Highly Crosslinked PMMA Nanoparticles and Their Application in Membrane and Opal Film were synthesized [1].

Synthesis of Polystyrene nanoparticles, their Crosslinking, and their application in membrane fabrication are used in a wide variety of scientific and technological applications with high-value-added materials, such as ion-exchangers, medical and chemical application as absorbents and polymer-supported catalyst [2-3]. Especially, there are high demands for highly crosslinking polymer beads with superior heat and solvent resistance, mechanical strength to serve as a spacer for display panel, the slip property were improved for plastic film and conductive ball [4-5]. The recent typical technique, which was used in the preparation of monodisperse beads with micrometer diameter, a dispersion polymerization, was extensively studied [6-8]. This process is very attractive for large-scale preparation of such particles. Recently, the dispersion polymerization was studied to overcome the problem of flocculation and deformation from the influence of crosslinking [9-11]. However, there are no reports on the seeded dispersion process through the monomer absorption procedure prior to polymerization in the presence of crosslinking nanoparticles. In this work, the Synthesis of crosslinking Polystyrene Nanoparticles was carried out with divinyl-benzene (DVB), polymerization temperature and Polystyrene in Polystyrene Beads polymerization.

2. Experiment

2.1 Materials

Table 1

Materials	Description (Purity)	Company Supplier
Styrene (C_6H_8)	99%	Aladdin, shanghai, china
Divinyl benzene (DVB)	80%	Aladdin, shanghai, china
alumina Oxide, natural (Al_2O_3)	75 %	Aldrich Chemical Co. USA
Potassium persulfate (KPS	99.5 %)	Aldrich Chemical Co. USA
Sodium dodeyl Sulfate(SDS)	-	Sigma –Aldrich U.S.A.
Toluene (C_7H_8)	92.14%,	Shanghai,Lingfeng Chemical, Reagent Co. Ltd China
Tetrahydrofuran (THF) (C_4H_8O)	99 %	sinopharm Chemical Reagent Co.Ltd China

The above chemicals were used as soon as they were received, deionized water was used for the experiment.

2.2 Prewashed Styrene and DVB

Firstly, in a Pasteur pipette, a small piece of cotton was placed inside the pipette very carefully as a block and was gently put until it cannot be removed further down the pipette and the pipette was filled half of alumina (Al_2O_3) Natural and monomer (styrene or Divinyl benzene) pass through it. Styrene or Divinyl benzene was collected from the pipette into a clean graduated cylinder, then the styrene or Divinyl benzene was kept in a refrigerator before use.

2.3 Synthesis of Polystyrene nanoparticles

Polystyrene nanoparticles were synthesized by soap-free emulsion polymerization in a three-necked flask equipped with a reflux condenser and a mechanical stirrer. A typical synthesis of polystyrene nanoparticle (PSN) was as follows:
A 0.05 gm sodium dodecyl sulfate (SDS) was dissolved in 45 mL deionized water with magnetic stirrer at 30 ^{0}C

overnight. It was degassed for 30 minutes under N_2 gas. Then 12 mL of prewashed monomer (Styrene) was added and stirred at 290 rpm under N_2 gas for 30 minutes with magnetic stirrer, and the mixture was refluxed, and heated up to 80 ^{0}C. After 10 minutes, when the temperature reached to 80 ^{0}C, and then 0.12 g potassium persulfate, powder dissolved in 5mL deionized at 30 ^{0}C for 30 minutes was added to the mixture. Temperature of the reaction was kept at 80 ^{0}C, and then reaction was stopped after 8 hours. After cooling the mixture it was centrifuged at 10.000 rpm for 35 minutes to precipitate the Polystyrene beads. The separated Polystyrene nanoparticles were washed three times with deionized water and pure ethanol with recycle ultrasonic and centrifugation. The Polystyrene nanoparticles were dried in vacuum oven at 60 ^{0}C for 24 hours.

2.4 crosslinking polystyrene beads

Crosslinking Polystyrene nanoparticles beads are prepared by an emulsion polymerization using prewashing styrene monomer and DVB crosslinking agent, and an adequate amount of KPS in the absence of an emulsifier. The synthetic process modified in our laboratory was as follows: Polymerization was conducted in a 250 mL reaction flask by mechanically stirring under a nitrogen gas. Deionized water was added to the reaction flask and nitrogen gas was bubbled in the flask and continued throughout the reaction. The KPS dissolved in 50 mL of water was added. The ratio of DVB to monomer was controlled to 0.5–15 mol %. Polymerization was conducted at 80 ^{0}C temperature for 8 hours with a stirring rate of 290 rpm.

After the reaction was finished to remove from the oil bath and cooling down at room temperature, the resulting cross linking polystyrene beads were washed by centrifugation/ redispersion cycles with ethanol and deionized water three times to remove by-products. Finally, the beads were dried in a vacuum oven for 24 h and yielded a fine white powder.

2.5 Membrane fabrication

Non-cross-linking and Cross-linking nanoparticles were used for the fabrication of Membrane. The Membrane fabrication was composed of non-cross-linking and crosslinking Nanoparticles. It was found that Nanoparticles with cross-linkages are 13 % stable to organic solvents such as toluene and Tetrahydrofuran. In typical membrane synthesis procedure, 0.325 g Polystyrene with 0.325 g Polystyrene Cross linking were treated with 5 mL (Toluene or Tetrahydrofuran (THF) dissolved with ultra-sonication for 30 minutes then kept for 3- 7 days to obtain membrane sheets. The membrane structure was observed after the treatment of Toluene or Tetrahydrofuran. The main reason for the formation of non-close-packing can be ascribed to the swelling behavior of the cross-linking Nanoparticle during vapor treatment [12-15].

2.6 SEM Image (Test)

The resulting particles morphologies were observed by SEM which was carried out on a Sirion 200 SEM at an accelerating voltage of 10 kV. To prepare samples for SEM, a drop of the dialyzed particles dispersion was dropped on a clean silicon wafer, and it was followed by triple rinsing in ethanol with ultrasonic cleaning for 30 min then nitrogen (N_2) gas was allowed to evaporate. Then, the samples were coated with a thin layer of gold.

2.7 TEM Tests

Investigation was performed on a FEI Tecnai G2 20 TEM microscope operated at an acceleration voltage of 200 kV. For TEM samples preparation, a drop of the very dilute dispersion was placed onto TEM copper grid pre-coated with carbon thin film. The samples were allowed to dry in an atmosphere and at room temperature for 1 day before observation.

3. Result and Discussion

The SEM images (1-2) of polystyrene crosslinking nanoparticles showed beads structure as clear in those images.

In the SEM, images (3-6) of Polystyrene nanoparticles showed beads structure in different solvents. The TEM images (7-8) of Polystyrene crosslinking nanoparticles showed beads structure and distribution. The TEM images (9-10) of polystyrene nanoparticles showed beads structure, distribution.

The SEM images (11-12) of membrane polystyrene treated Tetrahydrofuran (THF) showed smooth film surface.

The SEM image (13) and image showed a very clear polystyrene membrane structure film produced by treating polystyrene nanoparticle and Polystyrene crosslinking nanoparticles with Toluene solvent.

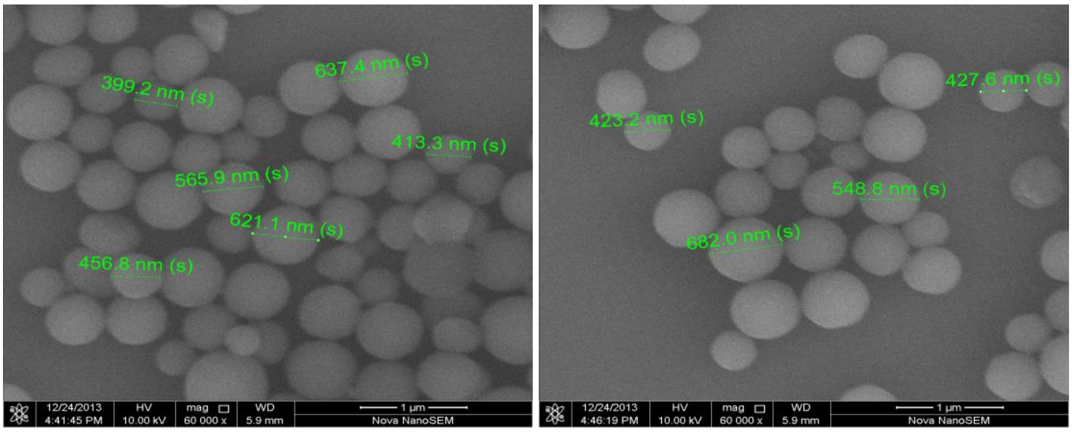

Fig 1: PS+DVB (Crosslinking polystyrene)

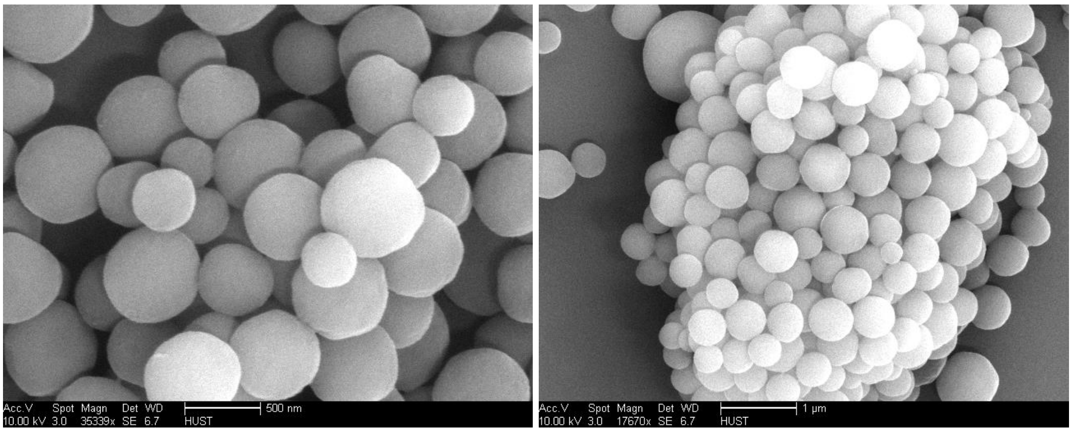

Fig 2: PS+DVB (Crosslinking polystyrene)

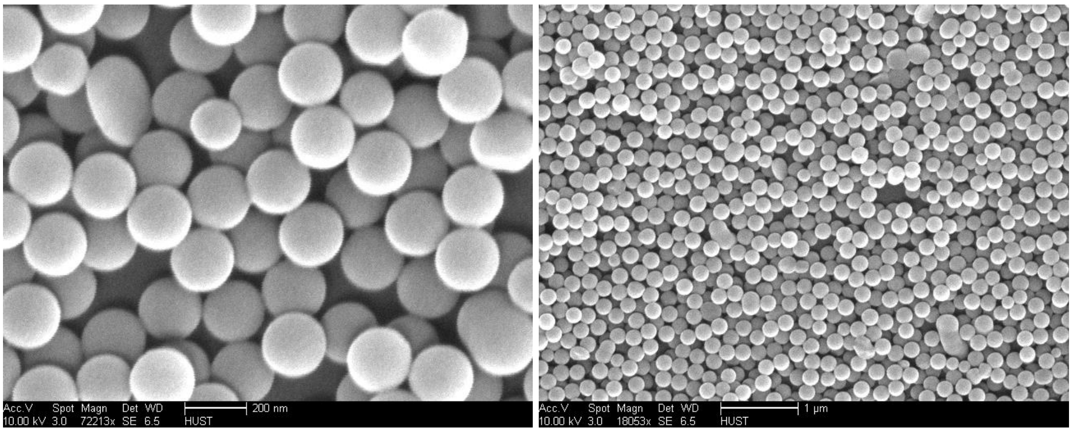

Fig 3: PS+SDS in Methanol

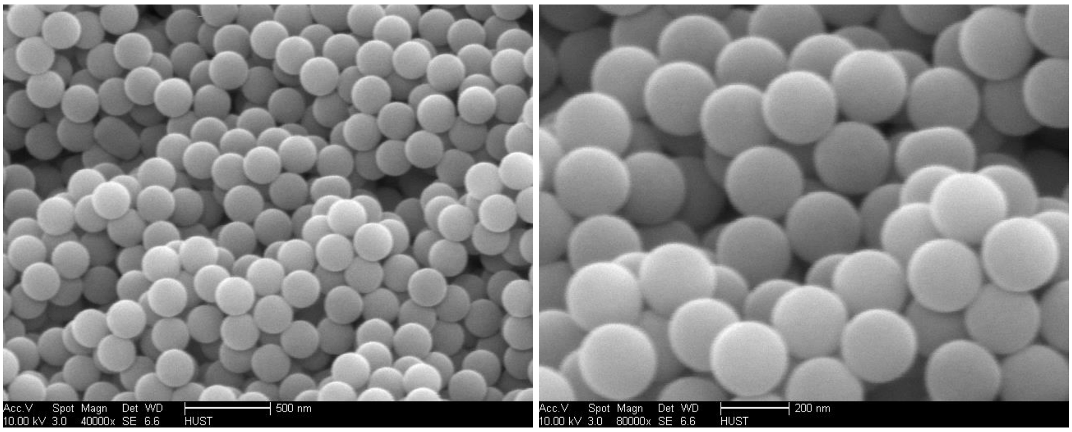

Fig 4: PS+SDS in Ethanol

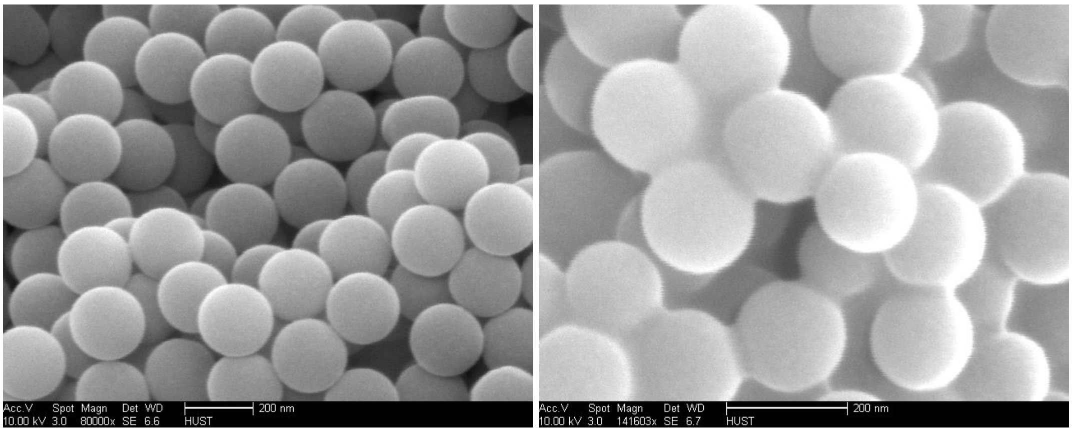

Fig 5: PS+SDS in Ethanol

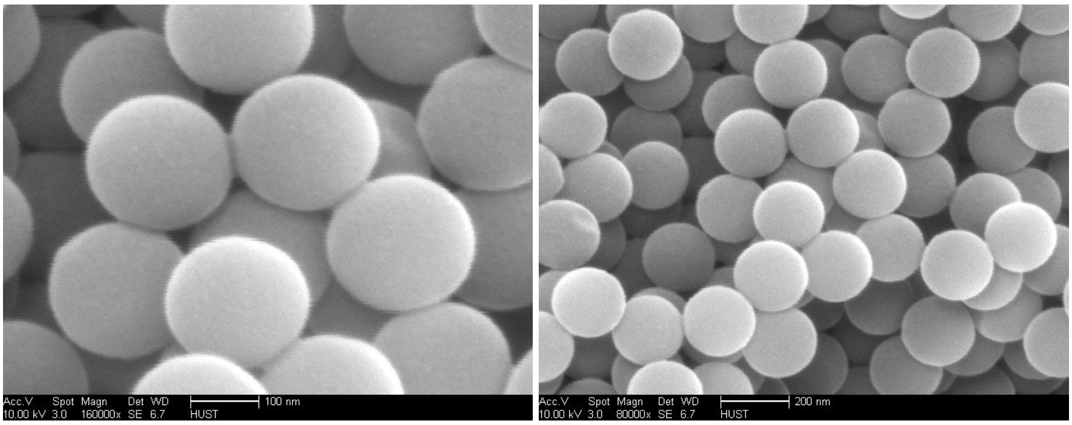

Fig 6: PS+SDS in H_2O

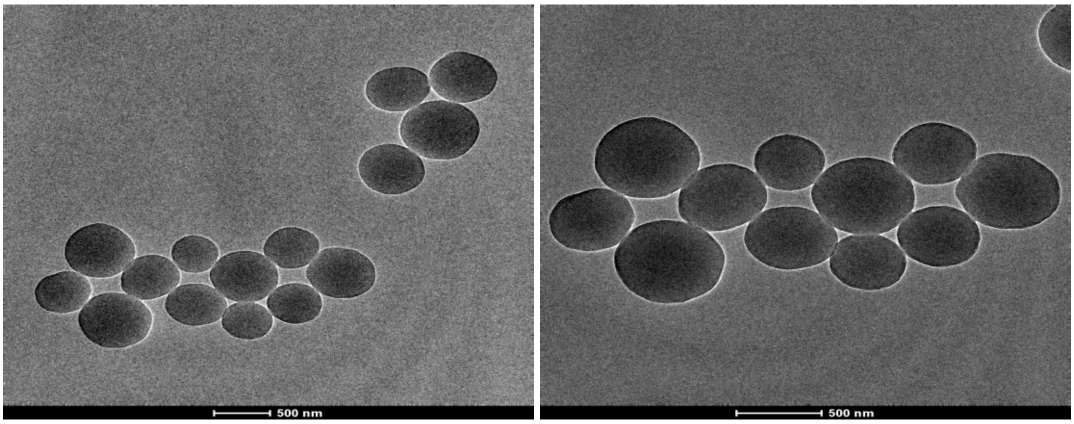

Fig 7: TEM PS+DVB in H_2O (crosslinking polystyrene)

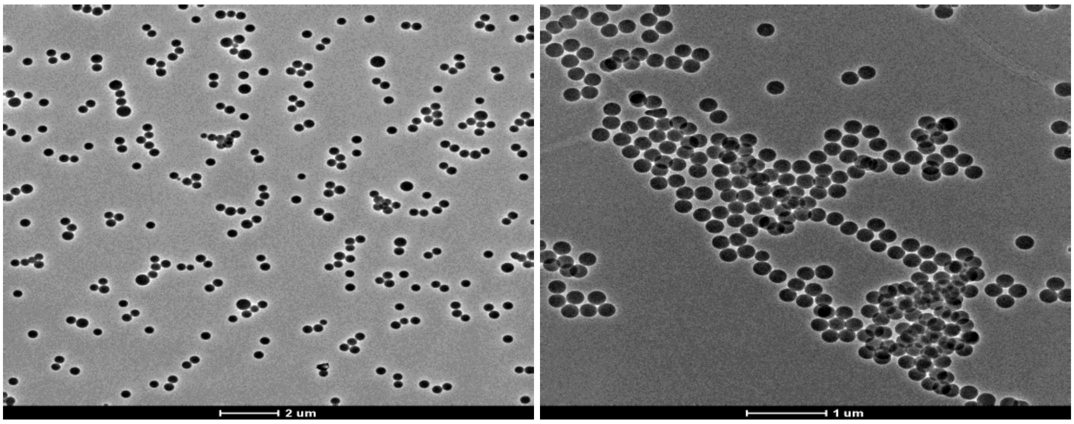

Fig 8: TEM PS+SDS in H_2O

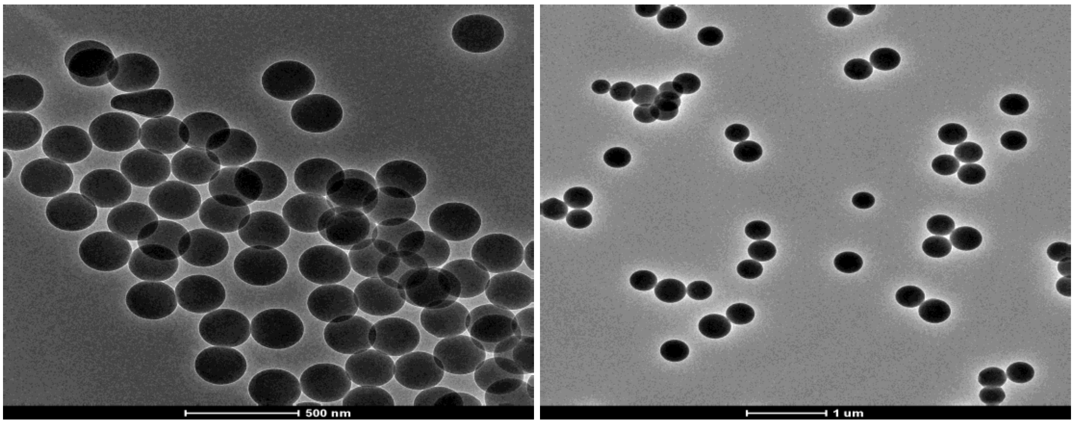

Fig 9: TEM PS+SDS in H_2O

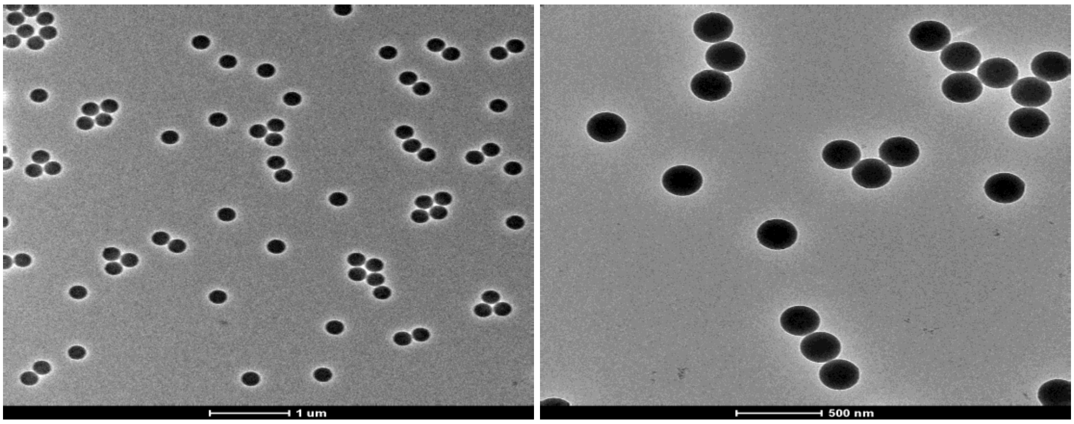

Fig 10: TEM PS+SDS in H_2O

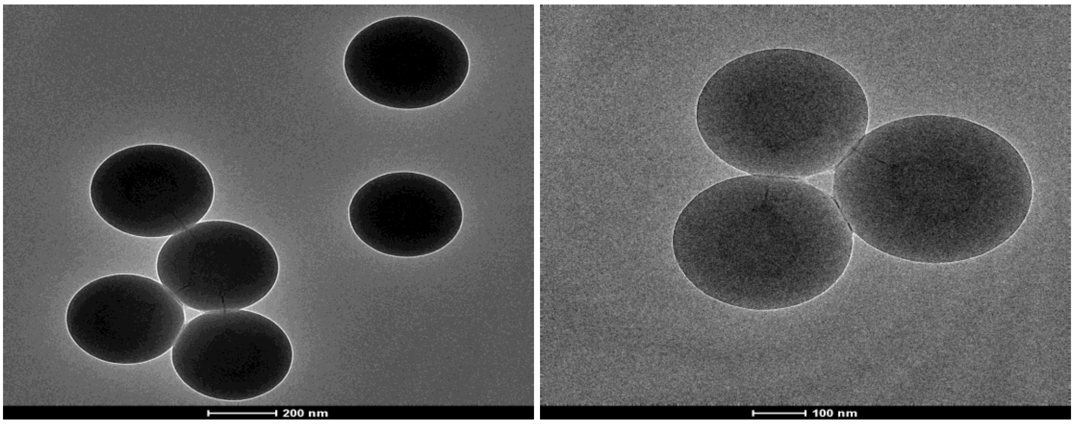

Fig 11: TEM PS+SDS in H_2O

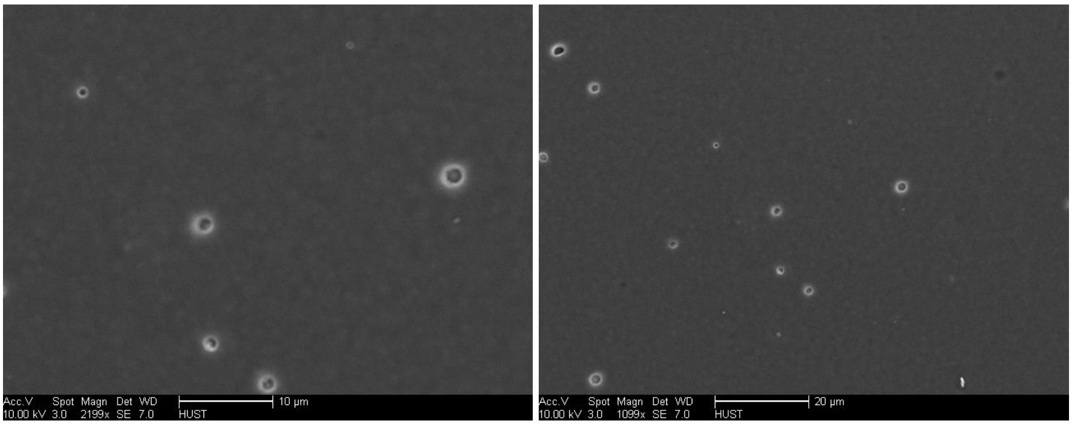

Fig 12: Polystyrene Membrane Film (PS +SDS) +(PS+DVB) treated with THF.

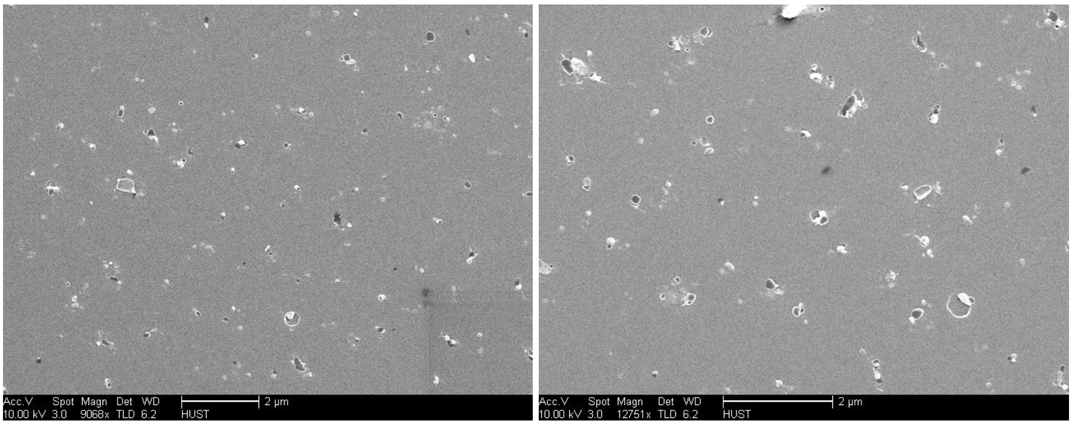

Fig 13: Polystyrene Membrane Film (PS +SDS) +(PS+DVB) treated with Toluene

4. Conclusions

In conclusion, I modified the synthesis polystyrene nanoparticles**.** The reaction was intendance under (N_2) gas at 80 ^{0}C temperature for 8 hours by using method of soap-free emulsion polymerization. The Polystyrene Crosslinking was modified in the same way. In addition, this method was used for the synthesis of nanoparticles with cross-linkages as high as 23%. The method shown here is also suitable for industrial production. The application of the Nanoparticle for membrane fabrication has shown that the nanoparticle are qualified for the construction of membrane fabrication. In particular, the cross-linking Nanoparticles are stable to some organic solvents, and the treatment of the membrane with organic solvents can result, in membrane fabrication with a non-close-packed structure, which is very useful.

5. Acknowledgements

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6. References

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