

Article

A Facile and Green Synthesis of Hydrophobic Polydimethylsiloxane Foam for Benzene, Toluene, and Xylene Removal

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Abstract: Due to its excellent properties, polydimethylsiloxane (PDMS) foam has recently attracted significant academic and industrial attention. In this study, a facile and green method was developed for PDMS foam synthesis. The PDMS foam was prepared by using the gas foaming method with eco-friendly materials, namely NaHCO₃ as a blowing agent and acetic acid as the catalyst. By changing the ratios of the reactants and the curing temperature, foams with varying properties were obtained. The water contact angle of the obtained PDMS foams ranged from 110° to 139°. We found that the PDMS foams can be compressed to a maximum strain of 95% and retain their original size, showing excellent mechanical properties. The synthesized PDMS foams were tested as an absorbent to remove benzene, toluene, and xylene (BTX) from the water. It exhibited good selectivity, outstanding reusability, and absorption capacity. Its capability to remove a large amount of organic solvent from the water surface suggests the great promise of PDMS foam in recovering spilled organic compounds from water, with excellent separation performance for continuous treatment.

Keywords: PDMS foam; gas foaming process; water contact angle; mechanical properties; BTX; absorption; recyclability



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1. Introduction

Polydimethylsiloxane (PDMS) porous polymeric materials such as polydimethylsiloxane (PDMS) foam have recently attracted significant academic and industrial attention as a novel porous polymeric foam material. The high bonding energy of the Si-O-Si backbone endows PDMS foam with excellent properties, such as thermal stability, mechanical flexibility, non-flammability, and nontoxicity. The PDMS in foam structure has functional properties such as high porosity, low bulk density, simple fabrication, low cost, and remarkable reusability compared to other polymers [1–3]. Moreover, PDMS has a low surface energy, due to the nature of the bonding and the low intermolecular forces between the side chains, giving this polymer superhydrophobicity [4,5]. Due to its distinctive porous structure and exceptional physical properties, PDMS foam has attracted considerable interest for various applications, including sensors [6–10], microfluidics [11–13], flexible conductors [14,15], adsorbents [16–18], absorbents [19–22], and oil/water separation [23–26]. One of the most important applications of PDMS foams is the separation of oil from water, including BTX. BTX are mono-aromatic volatile organic compounds that are liquids at typical room conditions. BTX are found in a wide range of petroleum products, such as gasoline, solvents, and diesel fuels. BTX are used as starting compounds in the chemical industry to produce a variety of secondary products, such as plastics, resins, detergents, inks, adhesives, and paints. BTX are considered some of the most frequently found contaminants present in

surface and groundwater. Because of their severe hazardous and carcinogenic properties, BTX negatively impact human health, even at low concentrations. In addition, BTX exposure can cause skin, eye, and mucous membrane irritation, as well as catastrophic nervous system deficits and leukemia [27–30].

Many approaches have been applied to prepare PDMS foams, such as porogen leaching (the template method), emulsion templating, and gas foaming. In the porogen leaching method, a sacrificial material known as a porogen, such as salt, sugar cubes, ZnO powders, Ni foam, and polymer particles, is incorporated into the PDMS mixture before curing. Once cured, the porogen is removed by leaching, leaving a porous structure behind [18,31–40]. Although porogen leaching methods have been utilized in numerous studies, they are time-consuming and cannot be used for large-scale synthesis.

The emulsion templating method involves the formation of an emulsion of two immiscible liquids, where one liquid is a continuous phase, and the other is a dispersed phase. After polymerization, the dispersed phase is removed, resulting in the formation of a porous structure. Typically, PDMS foams are produced from prepolymer-water emulsions. Several factors, such as the type of emulsifier, the polymerization conditions, and the processing parameters, significantly influence the morphology and properties of the resulting PDMS foams [3,41–46]. However, the emulsion method is also time-consuming and requires hazardous solvents, and the surfactants used in the emulsion method affect the produced foams' properties and need to be removed.

In the gas foaming technique, a foaming agent is introduced into the process in order to produce an inert gas that generates pores with various structures. The gas foaming technique can be physical or chemical [47–49]. The reported studies that used the gas foaming method to prepare the PDMS foam were either combined with other methods or used additional harmful solvents, making it complicated and time consuming. The pore structure and absorption capacity of PDMS sponges can be controlled by using different diluent ratios, due to their effect on generating gas in the gas foaming technique [49].

This work reports a new, facile, cost-effective, and time-saving method to prepare the PDMS foam via the gas foaming technique. The PDMS is polymerized using eco-friendly and non-hazardous materials, namely NaHCO_3 as a blowing agent and acetic acid as the catalyst. No cumbersome instrumentation is needed, making it suitable for large-scale production. Synthesized PDMS foams are characterized by their morphology, density, and elastic modulus, and their performance in absorbing BTX from water is evaluated.

2. Materials and Methods

2.1. Materials

Sylgard 184 silicone elastomer prepolymer (Sylgard 184A) and the thermal curing agent (Sylgard 184B) were purchased from Dow Corning (Midland, MI, USA). Benzene, toluene, and xylene were purchased from System Chemicals (Shah Alam, Malaysia). Sodium bicarbonate (NaHCO_3) and acetic acid were obtained from R&M Chemicals (Subang Jaya, Malaysia). All chemicals were used without purification.

2.2. Preparation of PDMS Foams

The PDMS prepolymer liquid was obtained by mixing the base and curing agent in a ratio of 10:1 by mass. NaHCO_3 and acetic acid were then added in ratios of 1:1, 1:2, and 2:1 (where 1 = 5% and 2 = 10%, by mass of the PDMS prepolymer). The mixture was hand mixed for a few seconds and then placed in the oven at the desired temperature (80, 100, and 120 °C) for one hour. The resulting foams were washed with water and then dried at the same curing temperature for one hour. The schematic preparation of the PDMS foam is illustrated in Figure 1, while the reaction conditions are listed in Table 1.

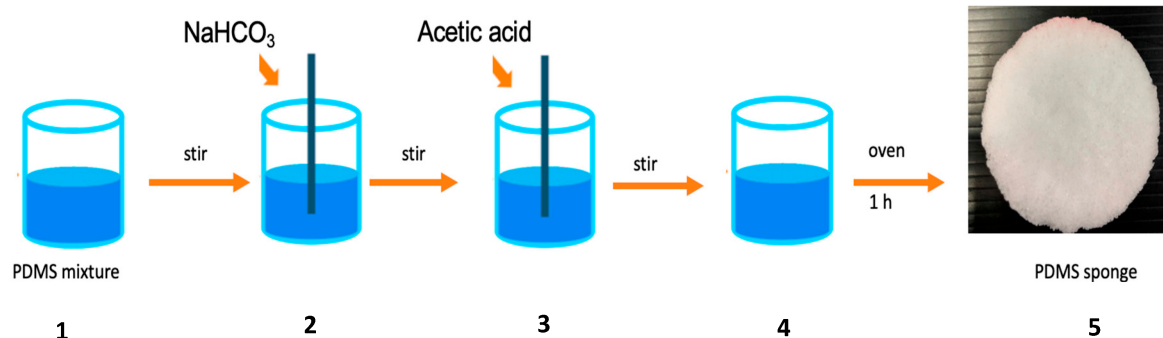


Figure 1. Schematic of PDMS foam production. (1) A mixture of the prepolymer and a curing agent. (2) Addition of NaHCO_3 . (3) Addition of acetic acid. (4) Curing in oven (5). The PDMS foam.

Table 1. The composition and reaction conditions for the preparation of the PDMS foam.

PDMS Foam	NaHCO_3 (%)	Acetic Acid (%)	Curing Temperature ($^{\circ}\text{C}$)
1:1(100)	5%	5%	100
1:2(100)	5%	10%	100
2:1(100)	10%	5%	100
1:2(80)	5%	10%	80
1:2(120)	5%	10%	120

2.3. Characterization

The PDMS foams' morphology was characterized using JEOL JSM-7600F (Tokyo, Japan), a field emission scanning electron microscope (FE-SEM), operated at a voltage of 5.0 kV. The SEM images obtained were analyzed with Fiji/ImageJ software, version 1.8.0. The pore size of the foam was determined by measuring the diameters as shown in the FESEM images using the Fiji/ImageJ software. The diameters of both large and small pores of the foam were recorded, and the average pore size was determined for each sample. Fourier transform-infrared spectra (FTIR) of samples were determined using a Thermo Fisher Scientific Nicolet iS10 (Madison, WI, USA) spectrometer within the wave number range of $400\text{--}4000\text{ cm}^{-1}$. The water contact angles were measured with a contact angle goniometer (OCA20, Dataphysics Instrument, Filderstadt, BW, Germany). Compression tests were carried out using a universal testing machine (Instron 3366 (Kawasaki, Japan), 10 kN) with a 10 kN limiting load and 20 mm/min of constant compressive speed.

To determine the density of the PDMS foam, the dimension and weight of a PDMS foam cube were measured using a micrometer, with an accuracy of 0.001 mm and an analytical balance and with a precision of 0.001 g, respectively. The sample volume was determined by its dimension, while the density was determined by dividing the weight of the foam by its volume.

The porosity of the foam was determined with Equation (1), as follows:

$$P = 1 - \frac{\rho}{\rho_{\text{PDMS}}} \quad (1)$$

where P is the sample's porosity and ρ and ρ_{PDMS} are the density of the foam and cured PDMS ($\sim 1.03\text{ g/mL}$), respectively.

2.4. The Absorption Study

The absorption capacities (q) of the PDMS foams were determined by soaking the foams with benzene, toluene, and xylene (BTX) at room temperature for 10 min. The absorption capacity of the foams was calculated using Equation (2), as follows:

$$q = \frac{W_1 - W_0}{W_0} \quad (2)$$

where W_0 and W_1 are the foam weights before and after the absorption of benzene, respectively. The absorption capacities of all prepared types of PDMS foam were compared using only benzene. Then, further experiments were carried out using the optimal foam. The experiments were also performed in water to evaluate the BTX/water selectivity index (SI) of optimum foam individually. The SI index is defined as the ratio of the mass absorption capacity in the BTX, $q_{(BTX)}$, to the mass absorption capacity in water, $q_{(water)}$, according to Equation (3), as follows:

$$SI = \frac{q_{(BTX)}}{q_{(water)}} \quad (3)$$

The recyclability of the foam was evaluated by repeated absorption–desorption processes. The foams were immersed in each absorbate of BTX until saturation. After recording the weight, the foams were manually squeezed to extract absorbates and reweighed before being used in the next absorption cycle. This absorption–desorption process was repeated ten times.

In addition to a simple BTX absorption and recovery method, the benzene/water mixture was continuously separated using a peristaltic pump. The separation process is as follows: one side of the rubber tube is attached to the PDMS foam and placed in the benzene/water mixture, while the other side of the rubber tube is placed in a clean beaker. Benzene was dyed with Sudan III for illustration purposes only.

3. Results and Discussion

3.1. Preparation of PDMS Foams

The PDMS foam was fabricated by using the gas foaming method, whereby the thermal decomposition of NaHCO_3 releases CO_2 gas during the crosslinking of the polymer (Figure 2 and Equation (1)). Acetic acid was introduced into a mixture of PDMS and NaHCO_3 to facilitate the release of CO_2 , which in turn created porous structures in the PDMS foam after heating the mixture in the oven.

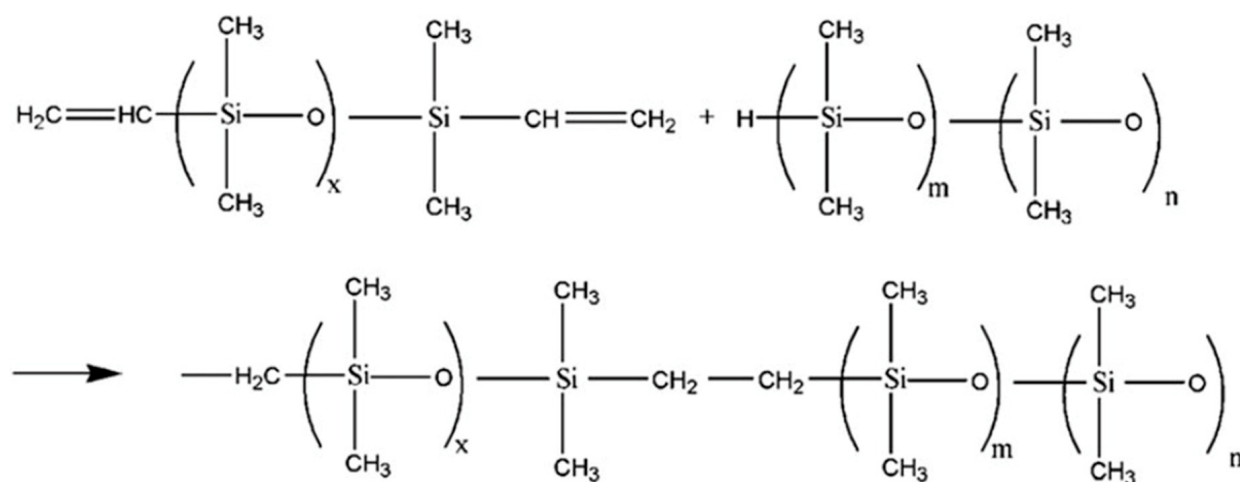
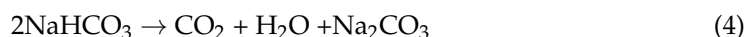


Figure 2. The crosslinking reaction of PDMS foams [20].

The thermal decomposition of NaHCO_3 , added as a foaming agent, started at approximately 50°C and generated CO_2 , water vapor, and sodium carbonate (Na_2CO_3), as illustrated in Equation (1) [50].



Acetic acid acted as a catalyst, as it reacts with NaHCO_3 and Na_2CO_3 to stimulate the release of CO_2 and, thus, the formation of pores, as shown in Equations (2) and (3).



Therefore, the pores of PDMS foam were generated by CO_2 gas derived from the decomposition of NaHCO_3 and the reaction of NaHCO_3 with acetic acid. These two process products left almost no residue in the pores, as the water evaporated during the heating process, while Na_2CO_3 and CH_3COONa were removed during the washing process. Since the pores of the PDMS foam were generated by CO_2 gas derived from these reactions, it is vital to determine the suitable conditions for producing a highly porous foam ideal for use as an absorbent. The weight of the resulting foams ranged from 10.89 g to 10.96 g when 10 g of silicone elastomer prepolymer and 1 g of curing agent were used, in addition to NaHCO_3 and acetic acid, as mentioned previously in Table 1.

3.2. Characterization of the PDMS Foam

3.2.1. Morphology

Effect of NaHCO_3 : Acetic Acid Ratios

The morphology of the PDMS foams prepared using different NaHCO_3 :acetic acid ratios (1:2, 2:1, and 1:1) and cured at 100 °C is illustrated in Figure 3a–c. These foams exhibited spherical interconnected macropores, with sizes ranging from 100 μm to 1000 μm (except for the 1:1 foam, where the size of some pores reached 1200), and connected micropores with diameters of less than 100 μm hence can be generally claimed to be homogeneous and uniform (Figure 3f–h) [37]. The PDMS foams produced using a higher acid content (1:2) and NaHCO_3 content (2:1) exhibited better pore homogeneity, which was possibly due to a faster and more significant amount of CO_2 being released during the curing process. Consequently, more cells formed simultaneously, resulting in smaller, finer, and more uniform pores in the foam. Through a close examination, the surface of the pore wall was quite rough, which could have contributed to the increased hydrophobic properties of the foams [6,43,44]. The foam pore size distributions (Figure 3k,l,m) showed that most of the pore sizes were less than 600 μm in diameter. The foam produced at a 2:1 ratio exhibited the smallest average pore size of 314 μm , followed by the 1:2 ratio (332 μm) and the 1:1 ratio (338 μm).

Effect of Curing Temperature

Since the rate of reaction between NaHCO_3 and acetic acid and the rate of PDMS curing are temperature dependent, the PDMS foams with a 1:2 ratio were prepared at three different temperatures, 80 °C, 100 °C, and 120 °C. The change in the curing temperature changed the amount of CO_2 gas released and, thus, affected the porous structure of the foams. The foam prepared at 80 °C (Figure 3d) showed a dense section in the middle of the foam. The foam prepared at 100 °C (Figure 3b) exhibited better pore homogeneity, which was possibly due to the significant amount of CO_2 that was released during the curing process. Consequently, more cells formed simultaneously, resulting in smaller, finer, and more uniform pores in the foam. In contrast, the foam that was prepared at 80 °C (Figure 3d) showed a dense section in the middle of the foam because the rate of carbon dioxide release was slow at low temperatures, which led to less expansion.

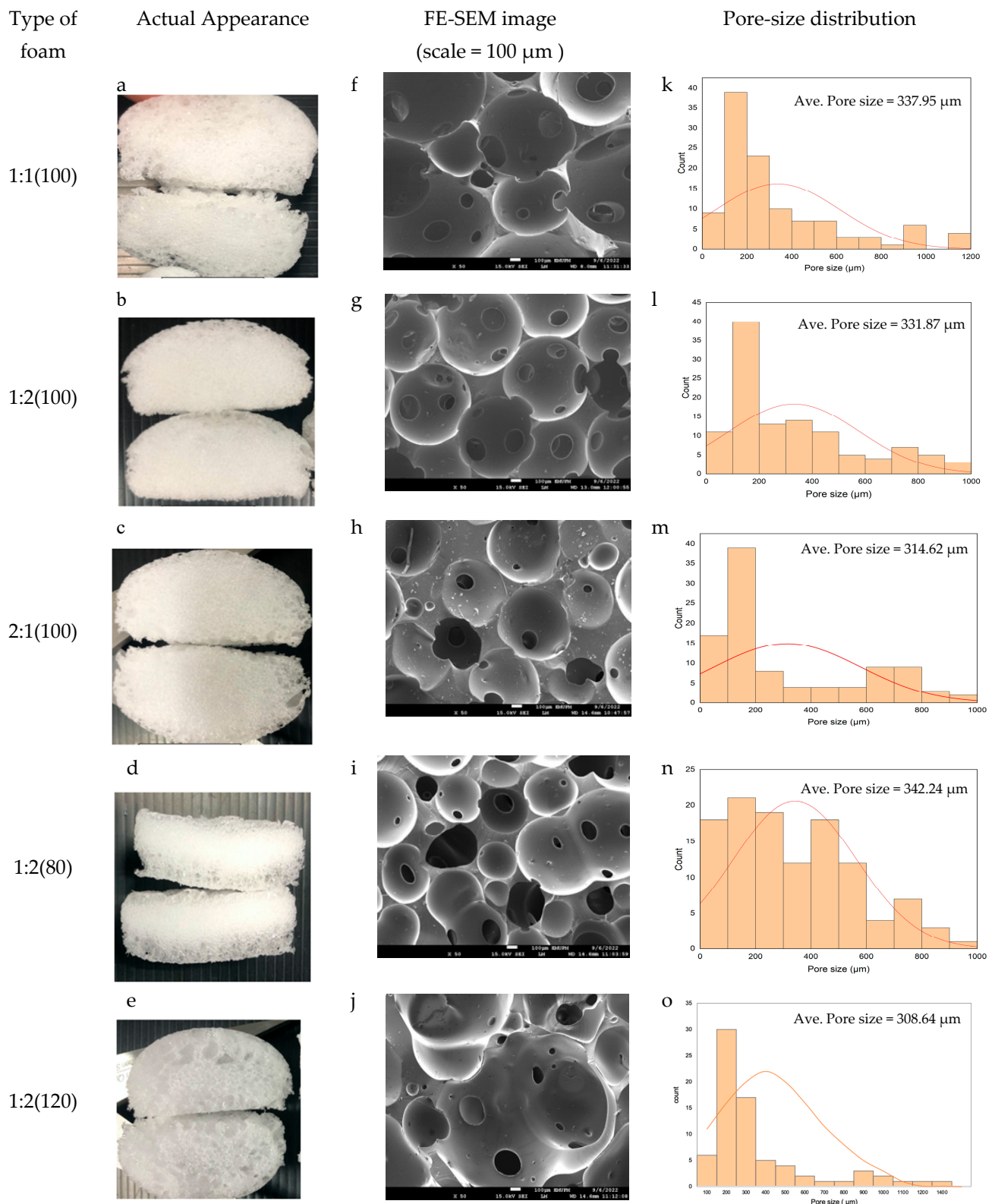


Figure 3. Photographic images (a–e), SEM images (f–j), and pore size distribution (k–o) of the prepared PDMS foams.

The pore homogeneity of the foam that was produced at 120 °C was found to be significantly less than that of foams made at lower temperatures (Figure 3f,i,j), and with a broader pore size range between less than 100 μm and 1400 μm (Figure 3k,n,o). This is

because the higher foaming temperature generated a higher pressure of carbon dioxide gases, which stretched the cell wall the most. This expansion of the cell walls led to a relative increase in the cell size, resulting in foam with lower pore homogeneity and broader pore size distribution [6,43,45].

3.2.2. Measurement of Density, Porosity, and Hydrophobicity

The effect of the NaHCO₃ to acetic acid ratio and curing temperature on the foams' density, porosity, and hydrophobicity properties was investigated. The results, tabulated in Table 2, show that the density of the foam is inversely related to the porosity of the foam, the higher the porosity, the lower the density. Only a slight change in porosity was observed with changes in the NaHCO₃ to acetic acid ratio. However, varying the curing temperature noted a significant difference in porosity.

Table 2. Density, porosity, and water contact angle of the PDMS foams.

PDMS Foam	Density (g/cm ³)	Porosity %	Water Contact Angle
1:1(100)	0.216	79	119.33
1:2(100)	0.247	76	139.42
2:1(100)	0.279	73	128.17
1:2(80)	0.348	66	110.42
1:2(120)	0.126	88	131.42

This finding can be correlated to the pore size distribution of the foam. The wettability of the surface of the foams was investigated by water contact angle measurement. The water contact angles ranged from 110° to 139° (Table 3), indicative of hydrophobic foams, with the 1:2(100) foam exhibiting the highest contact angle. The water-repellent nature of foam can be attributed to the presence of methyl groups, which tend to reduce its surface energy and tension. Consequently, the foam floats in water and can be wetted by organic solvents such as benzene (Supplementary Figure S1). The differences in the water contact angle at varying preparation parameters can probably be ascribed to the increased roughness of the foam surface. When the surface roughness increases, the hydrophobicity increases, leading to an increased water contact angle [51,52].

Table 3. Assignments of the main FTIR absorption bands of PDMS foams.

Wavenumber (cm ⁻¹)	Assignment
786.71	Si-CH ₃ stretching
843.75	-CH ₃ rock
1008.29	Si-O-Si stretching
1257.57	C-H bending
1411.58	C-H bending
2962.10	C-H stretching

3.2.3. Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectra of PDMS foams presented in Figure 4 and Supplementary Figure S2 revealed the functional groups of the foam. All of the PDMS foam types had identical FTIR spectra. The strongest absorption bands between 1100 and 1000 cm⁻¹ were characteristic peaks of the PDMS polymer backbone (Si-O-Si stretching). The second strong peak at 786.71 cm⁻¹ was due to Si-CH₃ stretching. The peak at 2962.10 cm⁻¹ was assigned to the methyl group (C-H stretching). The two absorptions at 1411.58 cm⁻¹ and 1257.57 cm⁻¹ arose from symmetric C-H bending. Table 3 illustrates the assignments of the PDMS foams' main FTIR absorption bands [20,34,53].

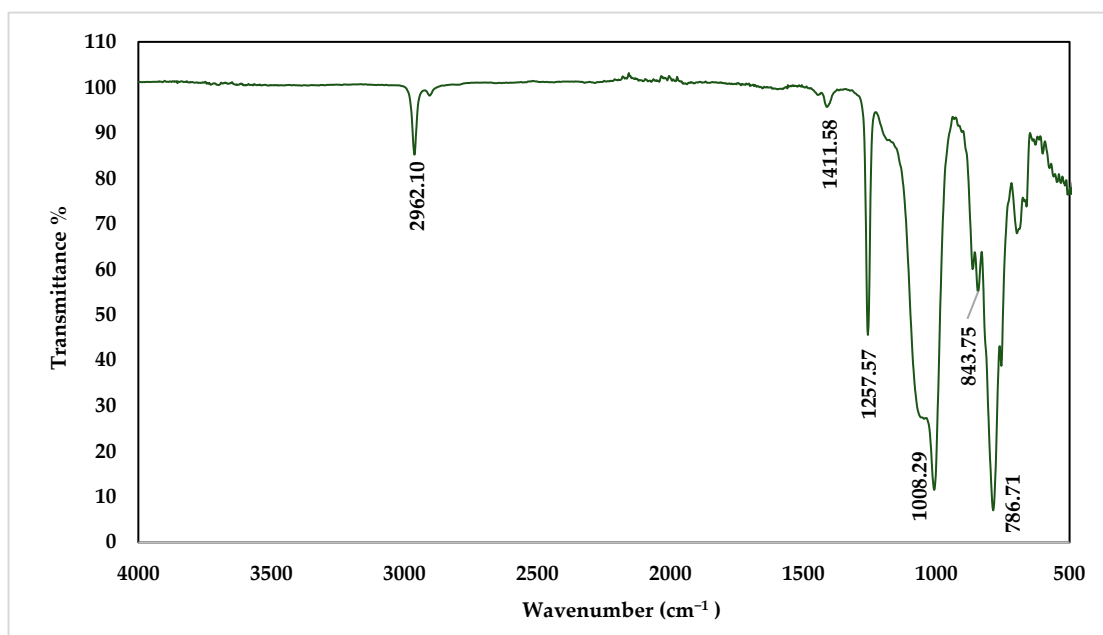


Figure 4. FTIR spectra of 1:2(100) PDMS foam.

3.2.4. Mechanical Properties

The compressibility of the foam is essential for determining its reusability. Figure 5 displays digital images of the compression and recovery processes of the PDMS foams in the mechanical test. All PDMS foams can be compressed to the maximum strain of 95% and retain their original size, showing excellent mechanical properties (Figure 6 and Supplementary Figure S3). Two regions can be distinguished in the strain–stress curve. The first region is the linearly elastic region, where stress increases slowly with the increase in strain, which gives a plateau. This can be explained by the presence of pores, which leads to large deformation at low stress. In the second region, stress increases rapidly due to the collapse of the pores and the deformation of the walls that form an approximate solid state [54,55].



Figure 5. Digital images of the compression–recovery process of PDMS foam in the mechanical test.

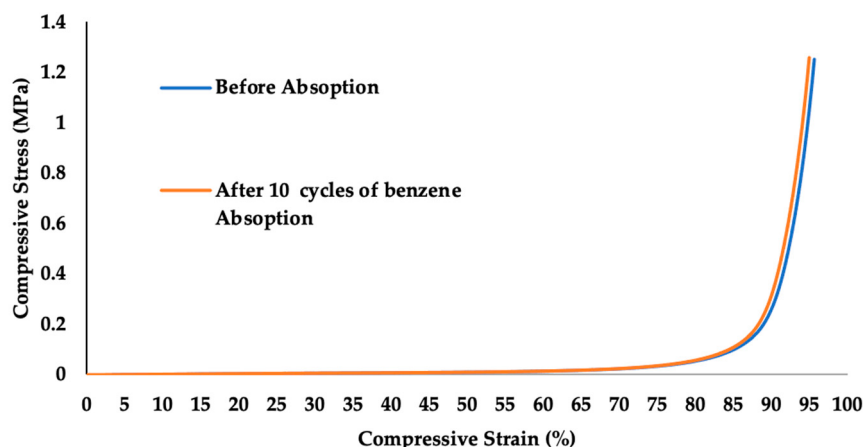


Figure 6. The stress–strain curve at 95% strain of 1:2(100) PDMS foam before absorption and after ten cycles of benzene absorption.

The stress–strain curve at 95% strain of the 1:2(100) PDMS foam before and after ten cycles of benzene absorption is shown in Figure 6. No noticeable change was observed, and the foam retained its original shape after decompression. The excellent elasticity of the PDMS foam is attributed to the elastic bending of the PDMS skeleton. It was remarkable that there was no collapse after ten cycles; consequently, excellent reusability and more entrapped absorbent can be extracted in order to achieve a higher recovery rate.

The modulus of the PDMS foams can be calculated by dividing the stress by the strain in the first elastic region, where stress grows linearly with strain at 50%. In general, the modulus values of the PDMS foams were very low, because a small load led to a significant change in strain. The increase in foam density resulted in a slight increase in the elastic modulus and compressive strength. The compressive strengths of the PDMS foams calculated from the end of the linear region at 50% strain are shown in Supplementary Table S1. The compressive strength is directly proportional to the foams' density. The foam with the lowest compressive strength and modulus was the 1:2(120) PDMS foam, which had the lowest density, while the 1:2(80) PDMS foam had the highest compressive strength and modulus. This can be explained by the fact that, as the density of a foam increases, the collapse of the pores and the deformation of the walls occur rapidly as the pore size is smaller. Therefore, more stress is required to produce the same strain change as foam with a lower density.

3.3. Absorption Study

3.3.1. Effect of Preparation Parameters on the Absorption of Benzene

Figure 7 shows a comparison of the maximum absorption capacity of all of the PDMS foams for benzene with 10 min of contact time. The differences in the absorption capacity at varying preparation parameters can probably be ascribed to the increased hydrophobic surface and porosity of the foams. The 1:2(100) foam has the highest absorption capacity, due to its higher hydrophobicity and medium porosity, which are responsible for a higher benzene retention capacity. When the porosity is high, as in the 1:2(120) and 1:1(100) foams, it seems that their ability to retain solvent is lower than that of the 1:2(100) foam, due to the presence of large pores. In contrast, the low absorption capacity of the 1:2(80) and 2:1(100) foams is attributed to their low porosity, leading to the low flow penetration of the foam.

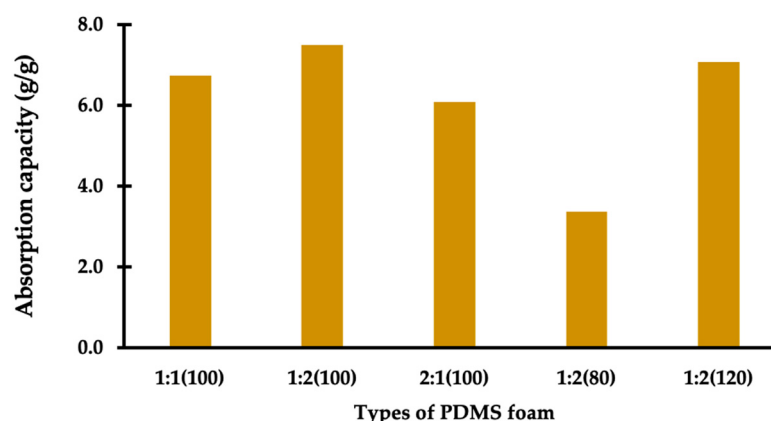


Figure 7. Comparison of maximum absorption capacity of all PDMS foams for benzene with 10 min contact time.

3.3.2. Absorption of BTX

The ability of the 1:2(100) foam to remove toluene and xylene was also evaluated. Figure 8 shows the maximum absorption occurring in the first minute, with a percentage exceeding 93%. Although there is no significant difference, the foam exhibits a higher absorption capacity toward xylene and toluene than benzene. This observation could be related to the strength of the hydrophobic interaction between the methyl groups of the polymer and the methyl groups of the compound, which increases with the increasing number of methyl groups and the hydrophobic character of the compound [56–58]. The results also show that the PDMS foam maintained its excellent absorption efficiency after ten absorption cycles of BTX, indicating its excellent stability and reusability.

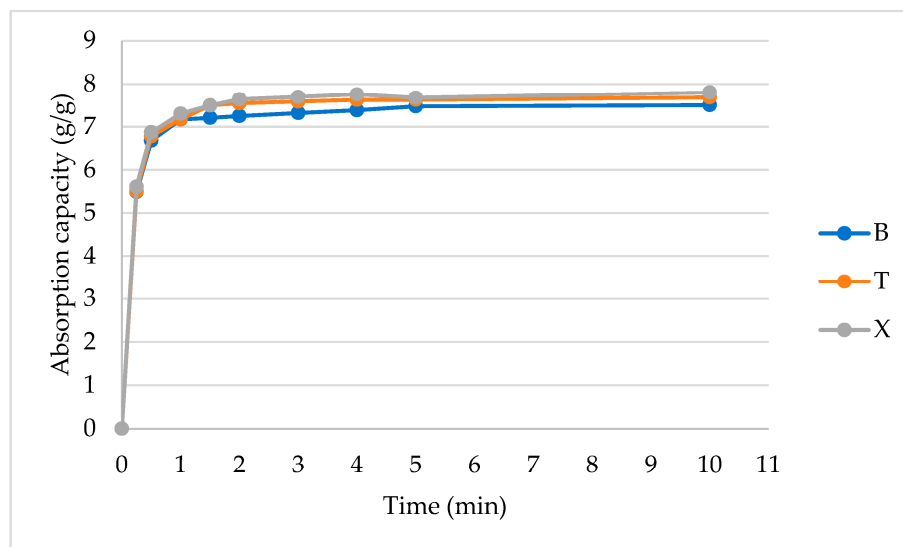


Figure 8. Comparison of the absorption capacity between B, T, and X by the 1:2(100) PDMS foam.

Table 4 shows a comparison of the properties and absorption capacity of the PDMS foams with other works. The absorption capacity of PDMS in this work is not the highest; however, the preparation method is considered more facile, eco-friendly, cost-effective, and timesaving. Moreover, no cumbersome instrumentation is needed, making it suitable for large-scale production. In addition, it exhibits the highest compression strain of 95%, which is essential in order for the foam to regenerate using the squeezing technique.

BTX/water selectivity indexes are 29.3, 29.7, and 30.5 for benzene, toluene, and xylene, respectively. The higher the SI values, the higher the selective absorption capacity of the

foam in the absorbate compared to water. Consequently, during pollutant spills in water, the foam, which floats in the water, absorbs the pollutants and reduces the unwanted absorption of water [59].

The recyclability of PDMS foam is a significant factor and provides both practical and economic benefits. The results show that the PDMS foam still had excellent absorption efficiency after ten absorption cycles of BTX (Figure 9), indicating its excellent stability and reusability.

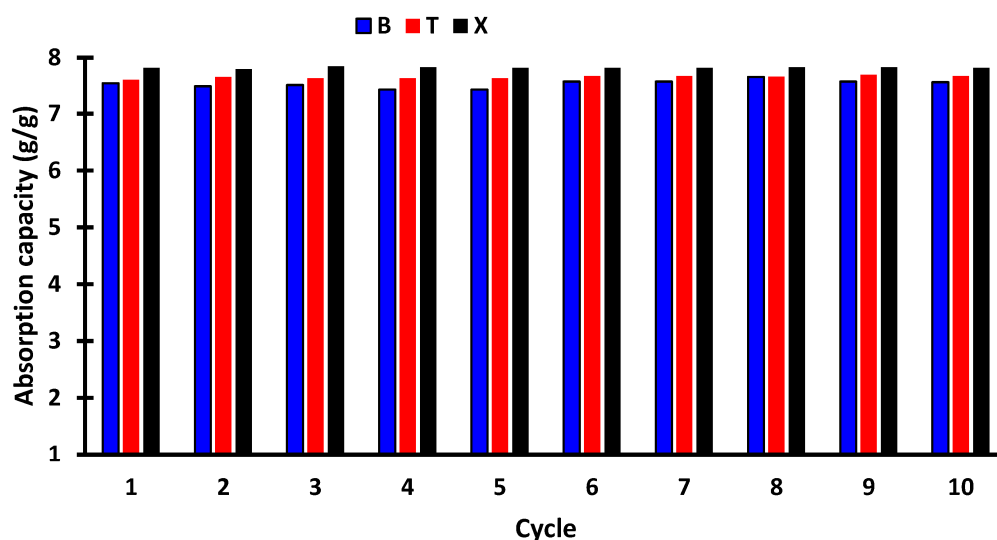


Figure 9. The reusability of the 1:2(100) foam in recovering BTX from the water surface.

3.3.3. Sorption from the Water's Surface

One distinct characteristic of PDMS foam is its ability to absorb hydrophobic compounds even from the water's surface. Figure S4 in the Supplementary Material demonstrates the effectiveness of PDMS foam in selectively absorbing benzene from water. The floating benzene on the water surface is absorbed by the PDMS foam within 10 s, indicating the high selectivity and quick absorption ability of the PDMS foam.

In many circumstances, dynamic absorption is more effective than static absorption, such as for collecting organic compound spills on the sea [60]. The continuous separation of benzene from water was successfully achieved using a peristaltic pump (Figure 10), showing great promise for PDMS foams in the continuous recovery of spilled organic compounds from water with excellent separation performance. This recovery method would not destroy the porous structure of the foam, as compared to the compression recovery method, hence prolonging the foam's use in oil/water separation.

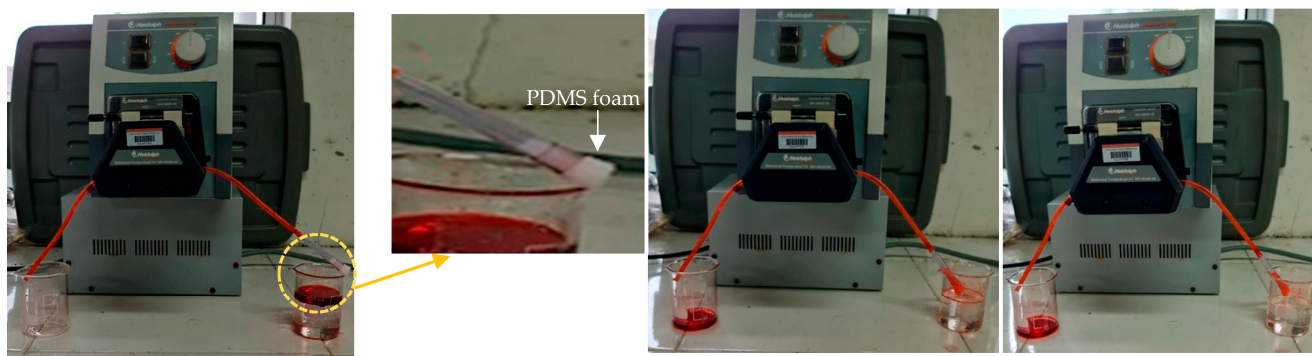


Figure 10. Schematic illustration of the different stages of using PDMS foam to continuously collect floating benzene (dyed with Sudan III) from water surface.

Table 4. Comparison of properties and absorption capacity of PDMS foams with those of other works.

Foam Material	Preparation Method	Density (g cm ⁻³)	Porosity (%)	Pore Volume (μm)	Maximum Compression Strain	Water Contact Angle (°)	Absorption Capacity for BTX (g/g)			Ref.
							B	T	X	
PDMS	Sugar particle template	0.18–0.75	N/A	N/A	N/A	120–130	-	4–5	-	[37]
AuNP/PDMS	Emulsion template	0.9–1.3	N/A	0.97–3.12	48–127%	N/A	3.5	4.5	6	[61]
PDMS/wax nanocrystal	Sugar cube template	0.28–0.43	56–71	50–100	N/A	151	9	13	10	[62]
AuNP/PDMS	Emulsion template		N/A	10–1000	N/A	N/A	-	6	-	[63]
PDMS/GO	Gas foaming	N/A	65.1–71.6	0.1–1000	80%	117.4–138.1		9		[64]
PDMS	Gas foaming	N/A	N/A	30–500	N/A	139	-	-	-	[19]
PDMS	Sugar particle template	0.12–1.1	43–84	N/A	60%	144	-	18.7		[65]
PDMS	Emulsion template	N/A	93	65.8–1768	90%	145.5	-	19	-	[41]
PDMS	Emulsion template	0.131–0.847	8.80–85.6	15–5000	90%	115–141	-	-	-	[44]
PDMS/Graphene	Salt template	0.14	80	N/A	70%	140–149	-	-	-	[66]
PDMS/Graphene	Sugar cones template	N/A	N/A	N/A	N/A	101–126	-	6	-	[67]
DMS/CNFs	Sugar cube template	0.425	N/A	N/A	50%	131–151	-	1.4	-	[68]
PDMS	Gas foaming	0.126–0.348	73–88	100–1400	95%	110–139	7.5	7.6	7.8	This work

4. Conclusions

A facile, eco-friendly procedure was successfully developed to produce porous PDMS foams via the gas foaming approach. The structural properties, namely the morphology, porosity, density, and mechanical properties of the foams, are affected by the NaHCO₃ to acetic acid ratio and the curing temperature. The 1:2(100) foam was the most effective in absorbing benzene, with an absorption capacity of 7.5 g/g, which can be attributed to its increased hydrophobic properties and medium porosity. The foam retains its excellent absorption efficiency after ten absorption cycles of BTX, indicating its excellent stability and reusability. This work shows the great promise of PDMS foam in recovering spilled organic compounds from water, with excellent separation performance for continuous treatment.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/separations10070377/s1>, Figure S1: (a) The PDMS foam float on water; (b) Optical images of the wetting behaviors of water and benzene droplets on the surface of PDMS foam; Figure S2: FTIR spectra of 1:1(100 °C) and 2:1(100 °C) PDMS foams; Figure S3: Stress-strain curves for the prepared PDMS foams at strains of 95%; Figure S4: Absorption of benzene, stained with Sudan III dye, by the 1:2(100) PDMS foam; Table S1: The modulus and the compressive strength of the PDMS foams.

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