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A Novel Porous Polymers Manufacturing Technique

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Abstract

There are many applications of porous materials, including the polymer, water, and metal filtration units of various industries; catalytic substrates; fuel cell components; surgical masks for doctors; "gortex" gloves for skiers; etc. In this paper, we discuss a novel method to make porous polymers. This method utilizes a mixture containing a biological agent (such as fungi) and a polymer. Characterization of the samples using the optical microscope and the scanning electron microscope (SEM) will also be discussed.

1. Introduction

Porous materials play a significant role in the international market and account for revenue totaling billions of dollars. The applications of porous materials are varied and include: thermal insulation, ion exchangers, filters and purifying systems, bone implants, Gortex clothing, catalytic substrates, porous battery electrodes, fuel cells, aerators, sorbents, silencers, kiln furniture, fiber optics, etc.[1-13]

Porous materials are characterized by their size distribution, shape, pore size, extent of interconnectivity and amount of porosity (open or closed).[8] The manufacturing techniques vary depending on the application for the porous material that is to be produced. For industrial applications, it is essential that the method chosen to produce the porous material is cost effective. This calls for developing novel techniques for the manufacturing of porous materials, especially porous polymeric materials.

In this paper, a novel technique to produce porous polymers using a biological agent is discussed. This method is based on the concept that a biological agent consists primarily of water, and if a the biological agent is dispersed in the polymer system, upon its death the biological agent will leave behind a pore in the material. Death of the agent occurs with time, by heating to elevated temperatures, or when the nutrient materials are exhausted. The size and shape of the pore will be that of the biological agent used. Here we discuss using a single celled fungus that is approximately one micron in size.

2. Experimental Procedure

2.1 Materials used

In this experiment, the polymer used was methylcellulose, commercially available from Dow. The biological agent used was a single celled fungus. The nutrient material needed for the single celled fungi to grow consisted of glucose ($C_6H_{12}O_6$) and de-ionized water.

2.2 Procedure

Measured amounts, 2 grams of the polymer methylcellulose, 1 gram of sugar, 2 grams of yeast, and 15 mL of water were used. The polymer (methylcellulose) was added with the de-ionized water after the water was heated to boiling. This was done to hasten the process of dissolution of the polymer. After the polymer dissolved in the liquid medium, the single celled fungi and glucose were added to this solution. The resulting mixture was allowed to dry for 48 hours. The pores in the samples were characterized using a scanning electron microscope (SEM).

3. Results and discussion

In the experiments, a biological agent (a single celled fungus) was used to generate pore in the structural material. The single celled fungus consumes glucose to grow and multiply. Upon consuming the glucose, the single celled fungus produces carbon dioxide gas and alcohol as waste. There are two mechanisms by which pores are generated in the material: the CO_2 gas produced creates pores, and the single celled fungi die leaving behind a pore, as they are comprised primarily of water. Equation 1 shows the reaction that takes place for the first case that was mentioned for the pore formation in the material.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 \qquad (1)$$

SEM images were taken to show the porosity in the materials made using this new process. The size distribution and shapes of the pores are seen clearly. Figure 1 shows a sample of the porous polymer. We can see that many pores are smaller than 10 micrometers. Interconnectivity is evident from this view as the pores can be seen inside of the pore walls. Interconnectivity can be important for filtration and other applications. The pores in the range of a micron are caused due to the collapse of the biological agent. Figure 2 is another SEM micrograph of a sample. Here we can see the many pores along with the variation in size distribution and shape of the pores.

These images display a large amount of porosity in the material. It is hypothesized that with careful control of the nutrient media, and the biological agent being used (bacteria, viruses, protozoa, fungi, etc.), the drying methods, etc., will greatly influence the size and size distribution of the pores in the polymeric structural material formed. This method can help reduce costs to make porous polymeric materials in industry. These biological agents are also relatively inexpensive.

4. Conclusions

A novel method for manufacturing porous polymers using a biological agent has been presented. A single cell fungus was used to form the porosity in the material. The porosity of the material has been characterized using the SEM.

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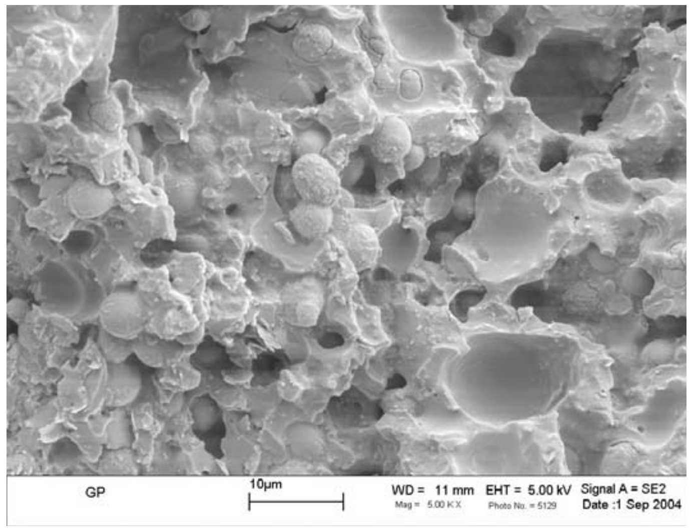

Figure 1. SEM micrograph of a porous polymer based structural material.

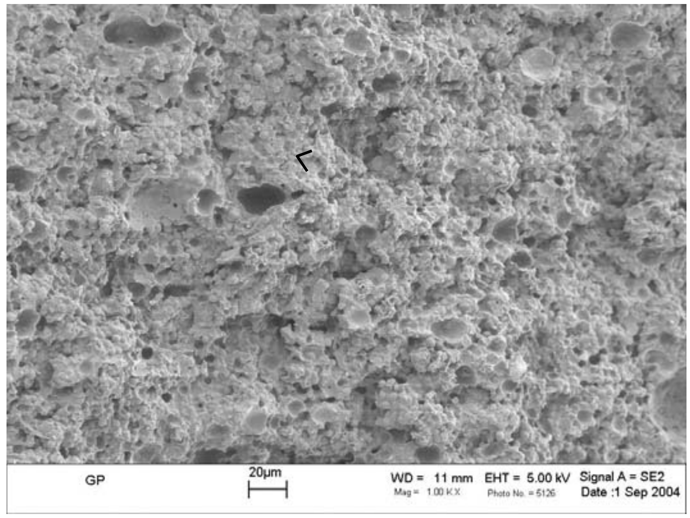

Figure 2. SEM micrograph showing pore size distribution.

This research was completed at Virginia Tech as an undergraduate research project.

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