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A New Biological Synthetic Route for Preparation of Silica Nano- Particles

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Silica nano-particles have been prepared by using E. colon bacillus (E. coli) as template. The particles accumulated on the inner wall of E. coli's cells. Their formation is related to the kinds of silicates. Sodium silicate can neither promote the breeding of E. coli nor provide the opportunity of silica formation. In contrast, tetraethylorthosilicate (TEOS) can easily be converted to silica. 100mg/L of aqueous TEOS appear to be an optimum concentration for the growth of E.coli.and silica formation.

Keywords: silica nano-particles; E; coli; template

INTRODUCTION

Due to many applications of silica nano-particles in catalyst carriers, separation technology, and biomaterial engineering, *etc.*[1], many methods of directing the formation of silica nano-particles have been explored extensively, i.e., lipid bilayer[2] and vesicle methods[3], and surfactant[4].Biomineralization also offers ideas and inspirations to achieve these particles, since they have been found on cell membranes of plants[5]. In this paper, we report a new template E. colon bacillus (E. coli) that possess a high breeding ability and are not prone to be infected by other bacteria. By an artificial culturing

method, silica nano-particles may be achieved on the inner wall of their cell membranes.

EXPERIMENTAL

E. coli (Kai Xuan Pharmaceutical Factory, Changchun), trypton and yeast extract (Unipath Ltd., Basingstoke, England) and tetraethylorthosilicate (TEOS, Shen Yang Third Chemical Factory, C.P.) were used as received. E. coli samples were incubated in a refrigerate incubator shaker (Mode: 4330) from New Brunswick Scientific Co. of the U.S. TEM images were taken on a transmission electron microscope of Japan (Mode: JE1200).

Culture mediums were prepared by admixing 10 g of trypton with 5 g of yeast extract, 9 g of NaCl, 100 mg of AMP, 1 L of water and TEOS (or sodium silicate) in certain concentrations. Then, E. coli species were added into the culture mediums. They were cultured at 30°C for 3 days and then in an incubator shaker at 42°C for 4h.

RESULTS AND DISCUSSION

In an effort to investigate the effect of silicates on the formation of silica inside E. coli's cells, two kinds of mediums were prepared, one, containing sodium silicate (1a), the other containing TEOS (1b). TEM images of the E. coli samples show that E. coli 1a (Fig. 1) do not possess silica particles, i.e., white dots, on the inner wall, as against E. coli 1b do. The radius of the particles is approximately in the range of 50-170nm. The facts illustrate that sodium silicate is not able to promote E. coli breeding and provide the opportunity of silica formation. Compared with Na_2SiO_3, TEOS can easily be assimilated by E. coli and converted to silica nano-particles depositing on their

inner walls.

FIGURE 1 TEM images of E.coli cultured in the mediums containing sodium silicate (1a) and TEOS (1b), respectively.

Additionally, we found that the growing rate of E. Coli 1b was associated with the concentration of TEOS in the medium. The faster E. coli bred, the higher the yield of silica nano-particles is. A relationship of the weight of the cultured E. coli and the concentration of TEOS is shown in Fig. 2. When the TEOS concentration is in the range of 20 to 80 mg/L, the change in E. coli's weight keeps stable. At 100 mg/L, the weight reaches the highest value. After that, it decreases rapidly. When TEOS reaches 200 mg/L in concentration, the growing of the E.coli 1b is completely restrained. It is suggested that at the initial stage of silica particles forming the permeability of the cell membranes be raised, which is beneficial to the E. coli 1b assimilating the nutrition and growing. In the medium with over 100 mg/L TEOS, this capacity might be reduced by sedimentation of much more silica on the cell wall of the E. coli. Furthermore, the absorption of the nutrition is restrained, and the E. coli are not able to continue to grow, even die.

The formation of silica particles can be further evidenced by a TGA curve of the pure cells (Fig. 3b). As reference, the TGA curve of the cells, which were incubated in the nutrition without TEOS under the same condition, was also measured in N_2 and shown in Fig. 3a. It can be seen that the weight of

two kinds of the cells all reduces with the increase in temperature. At 750°C, the weight loss of cells 3a and 3b is 30% and 40%, respectively. The difference of 10% can be contributed by the presence of silica.

In conclusion, silica nanoparticles (ϕ: 50-170nm) have been prepared by using E. colon bacillus (E. coli) as template in the presence of TEOS. The particles accumulated on the inner wall of the E. coli's cells. This fact was proved by TEM images and TGA measurements of the cells. 100 mg/L of aqueous TEOS appears to be an optimum concentration for silica formation and the growth of E. coli. In contrast, sodium silicate restrained the growing of E. coli and no silica nano-particles were formed.

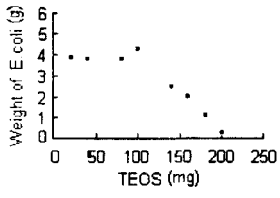

FIGURE 2. Change of silica weight with the concentration of TEOS.

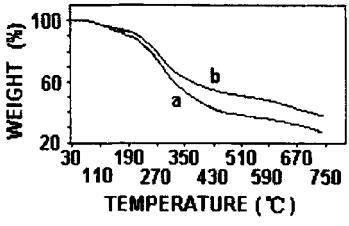

FIGURE 3. TGA curves of E coli cultured in the mediums without (a) and with TEOS (b).

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