

## Control 1 (C1)

15 g of chitosan, Profloc 320, was dissolved in 300 ml of an aqueous 0.05% acetic acid solution. The chitosan solution was air dried, resulting in a globular structure of a thin, brittle film. The surface area of the resulting material is shown in Table 1.

## Control 2 (C2)

15 g of chitosan, Profloc 320, was dissolved in 300 ml of an aqueous 0.05% acetic acid solution. 20 g of the chitosan solution were placed into a test tube and 30 ml of 0.2M tripolyphosphate was added to the test tube. The test tube was undisturbed for eight days to allow the chitosan to be ionically crosslinked. When the resulting ionically crosslinked chitosan body was air dried, the chitosan body shrank to form a compact material. The surface area and density of the dried chitosan body were measured, and the results are shown in Table 1.

## Control 3 (C3)

15 g of chitosan, Profloc 320, was dissolved in 300 ml of an aqueous 0.05% acetic acid solution. 20 g of the chitosan solution were placed into a test tube and 30 ml of 20% glutaraldehyde solution was added to the test tube. The test tube was undisturbed for eight days to allow the chitosan to be covalently crosslinked. When the resulting covalently crosslinked chitosan body was air dried, the chitosan body shrank to form a compact material. The surface area and density of the dried chitosan body were measured, and the results are shown in Table 1.

## Control 4 (C4)

A control specimen was prepared by following the procedure outlined in Example 1 (ii) of U.S. Pat. No. 4,125,708. Proflec 320 was ground to pass a 40-60 mesh screen, and 3.0 g of the ground chitosan was mixed with 22.5 millimoles of sodium dithionite and 15 millimoles of acetic acid in 30 ml of water. The mixture was stirred and held at 25° C. for 2 hours. The resulting solids were separated and washed with water (75 ml), methanol (15 ml) and then ethanol (75 ml), and air-dried.

The chitosan in this procedure did not form a gel, but it stayed as a suspension of insoluble solids. The surface area of the resulting particle was measured as shown in Table 1.

TABLE 1

| Example | SA<br>(m <sup>2</sup> /g) | ABD<br>(g/cm <sup>3</sup> ) | APD<br>(nm) | PA<br>(m <sup>2</sup> /g) |
|---------|---------------------------|-----------------------------|-------------|---------------------------|
| 1       | 93                        | 0.28                        | 51.0        | 124                       |
| 2       | 41                        | 0.34                        | —           | —                         |
| 3       | 50                        | 0.31                        | —           | —                         |
| 4       | 38                        | 0.32                        | —           | —                         |
| 5       | 20                        | 0.15                        | —           | —                         |
| 6       | 94                        | —                           | 141.0       | 84                        |
| 7       | 126                       | 0.23                        | 38.4        | 163                       |
| 8       | 37                        | 0.39                        | —           | —                         |
| C1      | 0.24                      | —                           | —           | —                         |
| C2      | 0.24                      | 0.7                         | —           | —                         |
| C3      | 0.2                       | 1.85*                       | —           | —                         |

TABLE 1-continued

| Example | SA<br>(m <sup>2</sup> /g) | ABD<br>(g/cm <sup>3</sup> ) | APD<br>(nm) | PA<br>(m <sup>2</sup> /g) |
|---------|---------------------------|-----------------------------|-------------|---------------------------|
| C4      | 1.5                       | —                           | —           | —                         |

SA = surface area  
ABD = apparent bulk density  
APD = average pore diameter  
PA = pore area  
\*particle density (g/cm<sup>3</sup>)

As can be seen from the above results, subjecting a solution of a nitrogen-containing hydrogel polymer with either an ionic crosslinking process or a covalent crosslinking process alone does not provide the porous bodies of the present invention that have a high surface area and physical integrity. In addition, as can be seen from the result of Control 4, unless the nitrogen-containing hydrogel polymer is solubilized and then crosslinked, the resulting crosslinked bodies do not form porous bodies and do not have a high surface area. In contrast, the nitrogen-containing polymer bodies that are produced in accordance with the present invention are highly porous and have a low density as well as high mechanical strength, making the porous bodies to be suitable materials for use as chromatographic support, resins for biomolecule separation columns, fillers, adsorbents, filters, membranes, insulation materials and the like.

What is claimed is:

1. A crosslinked porous body comprising a nitrogen-containing polymer crosslinked with an anionic salt solution and further crosslinked with a covalent-crosslinking agent selected from the group consisting of dialdehydes, aromatic dihalides, formaldehyde, epichlorohydrin, imidates, disulfonyl chlorides, diacid halides, aliphatic dihalides, bisepoxides, diesters, diazides, carbodiimides, aromatic and aliphatic diisocyanates, aromatic and aliphatic diisothiocyanates, aromatic bis-azido compounds, 1-fluoro-2-nitro-4-azidobenzene, p-azidophenacyl bromide, N-(azidonitrophenyl)-γ-aminobutyrate hydroxysuccinimide ester, genipin, butene-3,4-oxide, pentafluorobenzaldehyde, chlorobenzaldehyde, fluorobenzaldehyde, and mixtures thereof, wherein said porous body has an apparent bulk density of equal to or less than about 0.6 g/cm<sup>3</sup> and a surface area of at least 5 m<sup>2</sup>/g.

2. The crosslinked porous body of claim 1, wherein said nitrogen-containing polymer is selected from the group consisting of chitosan, poly(amino-styrene), poly(vinylpyridine), poly(diaminodiphenyl-methane), poly(aminoaniline), poly(ethylenimine), poly(vinylpyrrolidone) and mixtures thereof.

3. The crosslinked porous body of claim 1, wherein said nitrogen-containing polymer is chitosan.

4. The crosslinked porous body of claim 1, wherein said anionic salt is selected from the consisting of the ammonium, onium and metal salts of sulfate, phosphate, polyphosphate, tripolyphosphate, o-benzaldehyde sulfonate, pyrophosphate, trimetaphosphate and mixtures thereof.

5. The crosslinked porous body of claim 1, wherein said covalent-crosslinking agent is selected from the group consisting of glutaraldehyde, glyoxal, piperazine dicarboxaldehyde, succinic aldehyde, adipic aldehyde, maleic aldehyde, and mixtures thereof.

6. The crosslinked porous body of claim 1, wherein said covalent-crosslinking agent is glutaraldehyde.

7. A crosslinked porous body comprising chitosan crosslinked with a tripolyphosphate solution and further crosslinked with glutaraldehyde, wherein said porous body has an apparent bulk density of equal to or less than about 0.6 g/cm<sup>3</sup> and a surface area of at least 5 m<sup>2</sup>/g.

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