# United States Patent [19]

**Karwoski et al.**

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[54] **VASCULAR PROSTHESIS HAVING FLUORINATED COATING WITH VARYING F/C RATIO**


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[52] **U.S. Cl.** ..... **623/12;** 623/1; 623/66; 427/2; 427/255.6; 427/296; 427/41; 427/40; 128/334 R; 204/169; 428/395; 428/421

[58] **Field of Search** ..... 427/2, 255.5, 296, 255.6, 427/39, 40; 623/1, 11, 12, 66; 128/334 R, DIG. 14; 428/394, 395, 409, 422, 420, 421; 204/158 HA, 158.19, 169; 66/178 A, 194–197; 139/421–423



[56] **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 3,068,510 | 12/1962 | Coleman | 18/2 |
| 3,663,265 | 5/1972 | Lee et al. | 117/93.1 |
| 3,839,743 | 10/1974 | Schwarcz | 3/1 |
| 4,076,916 | 2/1978 | Lagow | 526/43 |
| 4,188,426 | 2/1980 | Auerbach | 427/40 |
| 4,193,138 | 3/1980 | Okita | 3/1.4 |
| 4,229,838 | 10/1980 | Mano | 3/1.4 |
| 4,252,848 | 2/1981 | Datt et al. | 428/64 |
| 4,264,750 | 4/1981 | Anand et al. | 525/356 |
| 4,286,341 | 9/1981 | Greer et al. | 3/1.4 |
| 4,349,582 | 9/1982 | Beerwald et al. | 427/38 |
| 4,404,256 | 9/1983 | Anand et al. | 428/409 |
| 4,488,954 | 12/1984 | Hatada et al. | 204/169 |
| 4,632,842 | 12/1986 | Karwoski et al. | 427/2 |
| 4,652,263 | 3/1987 | Herweck et al. | 128/334 R X |
| 4,656,083 | 4/1987 | Hoffman et al. | 427/2 X |

FOREIGN PATENT DOCUMENTS

54-56672 7/1979 Japan .

OTHER PUBLICATIONS

Garfinkle, Hoffman, Ratner, Reynolds, & Hanson–"Effects of a Tetrafluoroethylene Glow Discharge on Patency of Small Diameter Dacron Vascular Grafts", vol. XXX Trans Am. Soc. Artif. Intern Organs, 1984—pp. 432–440.

Yasuda, H.–"Glow Discharge Polymerization", vol. 16, Journal of Polymer Science: Macromolecular Reviews, pp. 199–293, 1981.

Yasuda & Hirotsu–"Critical Evaluation of Conditions of Plasma Polymerization" Materials Research Center, University of Missouri–Rolla, Rolla, Missouri 1977.

Yasuda & Hsu, "Some Aspects of Plasma Polymerization of Fluorine-Containing Organic Compounds. II. Comparison of Ethylene and Tetrafluoroethylene", vol. 16, Journal of Polymer Sci., 415–425 (1978).

Soong & Bell—"The Effects of Hydrogen on the Plasma Polymerization of Tetrafluoroethylene", vol. 21, Polymer Engineering & Science, Aug., No. 11 (1981).



(List continued on next page.)



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[57] **ABSTRACT**

Disclosed is a method of producing implantable prosthetic devices, e.g., tubular vascular prostheses having a substantially non-thrombogenic inside surface and a biocompatible outside surface. The method involves deposition onto an elongate substrate, e.g., a porous tubular substrate, of a fluorine-containing coating by inducing glow discharge progressively along the length of a tubular reaction vessel. A polymerizable fluorine-containing gas is flowed through the tubular substrate and a portion of the gas migrates radially to traverse the pores of the substrate. An RF field is applied to successive volumes of the gas within the vessel and tube. A substantially non-thrombogenic fluorinated coating with a first fluorine to carbon ratio deposits and bonds to the inside surface of the substrate, and a fluorinated biocompatible cross-linked coating with a lower F/C atomic ratio than the inside coating deposits and bonds to the outside surface of the substrate. The method of the invention can produce uniform coatings containing fluorine over the surface of elongated substrates. The coatings can be engineered to have a very low surface energy and to be essentially non-thrombogenic.


**15 Claims, 6 Drawing Figures**