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# United States Patent [19]

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**Onda et al.**

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[54] **MULTIPLE LAYERED FUNCTIONAL THIN FILMS**

J. Am. Chem. Soc., vol. 117, No. 22, pp. 6117–6123 (1995) article entitled “Assembly of Multicomponent Protein Films by Means of Electrostatic Layer-by-Layer Adsorption”.

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[57] **ABSTRACT**

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Multiple layered functional thin films fixed on a solid support are provided which comprise multiple layers of functional molecules (such as enzymes and other proteins, pigments and dyes) admixed with polymer ions in combination with multiple layers of polymer ions without the functional molecules. The films are prepared by immersing a solid support having an electric charge in an admixed polymer ion-functional molecule solution having a net electric charge opposite to that of the solid support followed by immersing the solid support in a polymer ion solution having a net electric charge opposite to that of the admixed polymer ion-functional molecule solution, and repeating at least once the immersions of the solid support in the solutions. Alternatively, the films are prepared by immersing the solid support in a polymer ion solution having a net electric charge opposite to that of the solid support followed by immersing the solid support in an admixed polymer ion-functional molecule solution having a net electric charge opposite to that of the polymer ion solution, and repeating at least once the immersions of the solid support in the solutions.

[22] Filed: **Sep. 10, 1997**

[30] **Foreign Application Priority Data**

Sep. 30, 1996 [JP] Japan ..... 8-280329

[51] **Int. Cl.<sup>7</sup>** ..... **C12N 11/00**; C12N 11/08; C07K 17/00; C07K 17/08

[52] **U.S. Cl.** ..... **435/180**; 435/174; 435/176; 435/178; 435/182; 530/402; 530/810; 530/811; 530/813; 530/815; 530/817

[58] **Field of Search** ..... 435/174, 176, 435/178, 180, 182; 530/402, 810, 811, 813, 815, 817

[56] **References Cited**

**PUBLICATIONS**

Biotechnology and Bioengineering article entitled “Sequential Actions of Glucose Oxidase and Peroxidase in Molecular Films Assembled by Layer-by-Layer Alternate Adsorption” vol. 51, pp. 163–167 (1996).

**24 Claims, 7 Drawing Sheets**