Patenting Activity in Biosensors

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An analysis of 150 patents filed in USA during 1983-95 indicates that USA and Japan are the leading countries filing patents in this area of technology. The patenting activity is highly scattered among institutions and companies. It is concentrated in the areas of enzyme membrane biosensors and electrochemical biosensors.

Biosensors are devices, usually miniature in size, providing real time, on-line monitoring of some compounds of biological interest. These sensors use biologically based mediators (e.g. enzyme, bacteria, other living cells and immunological reagents). They find applications in medical diagnostics, analysis of food samples, and in environmental monitoring. With the growing importance of biosensors and the massive investments and efforts being made in R&D all over the world, the question of securing adequate protection of new innovations in the field has assumed considerable importance. The present paper aims to study innovative activity in the field of biosensors during 1983-95. Author has chosen to study the innovative activity in this field because 'biosensors' is perhaps the most exciting area of electrochemical sensor research today.

Data and Methodology

Information on patents can be searched by name of an inventor. The name of the inventor is clear and unique and search through the name of the inventors is very simple. This type of search, however, does not result in substantive output and is time-consuming as patents for each company or for an individual is to be made separately. This type of search is done only when rival companies want to identify the areas of their competitors. However, substantive search helps in locating all the documents belonging to a given technical field. Substantive search can be made by using International Patent Classification (IPC) and database specific classification. Keywords of technical fields are also used to identify the patents in that field.

In the present exercise using the technical keywords of the field, the patents filed on
biosensors were obtained by searching the US bibliographic patent database at the National Informatics Centre (NIC), New Delhi. Following technical keywords were used:

(Biosensors* or Bio-sensor* or Bio adj Sensor* )
(Enzyme * Sensor*) not (Biosensor* or BioSensor* or Bio adj Sensor*)
(Microbial* and Sensor*) not (Biosensor* or BioSensor* or Bio adj Sensor*)
(Immunosensor* or Immuno-sensor* or Immun* adj Sensor*) not (Biosensor* or BioSensor* or Bio adj Sensor*)

The search resulted in 150 patents (Annexure 1) containing information on patent number, issue date, assignee’s name, country of the assignee, classification number according to US patent system, and title of the patent.

The data was processed and the above parameters were used to study different aspects of patenting activity in biosensors. Issue date was used to study the growth of patents, assignee’s name was used to identify leading companies, countries name was used to identify the countries filing patents in this area of technology and by picking a keyword from the title we identified the areas where maximum patents were being filed.

Results

Growth in Patenting Activity

The number of patents being filed on biosensors has risen during 1983-95 both in absolute terms (from one in 1983-85 to 75 in 1992-94) and perhaps more importantly, as a percentage of the total number of patents filed (from 0.66% in 1983-85 to 50% in 1992-94) (Table 1). The sudden growth of biosensor patents during 1989-94 indicates a spurt in number of countries and companies involved in the innovative activity in this area of technology. The trend of growth clearly indicates that this is an area of growing importance in scientific research.

Inter-country Comparison

Table 2 shows the number of patents for different countries and years in blocks of three years each. USA and Japan are the main patenting countries followed by UK. However, Japan was the first country to file a patent in this field. Analysis of data indica-

Table 1 - Growth of patenting activity

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of patents filed</th>
<th>Percentage of total output of patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983-85</td>
<td>1</td>
<td>0.66</td>
</tr>
<tr>
<td>1986-88</td>
<td>6</td>
<td>4.00</td>
</tr>
<tr>
<td>1989-91</td>
<td>27</td>
<td>18.00</td>
</tr>
<tr>
<td>1992-94</td>
<td>75</td>
<td>50.00</td>
</tr>
<tr>
<td>1995</td>
<td>41</td>
<td>26.66</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>99.32</td>
</tr>
</tbody>
</table>

Table 2 — Distribution of patents according to patenting countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>12</td>
<td>23</td>
<td>75</td>
</tr>
<tr>
<td>Japan</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>37</td>
<td>23</td>
<td>75</td>
</tr>
<tr>
<td>UK</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Germany</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Sweden</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>6</td>
<td>27</td>
<td>75</td>
<td>41</td>
<td>150</td>
</tr>
</tbody>
</table>
cates that during 1983-91 only USA, Japan, UK and Germany were filing patents. However, in 1992-94 many other countries namely Sweden, France, Korea, Australia, Canada, Austria, Israel, The Netherlands, Singapore, Norway, Taiwan and China became active resulting in a steep rise in number of patents.

Competitiveness among Firms

By analysing the name of the assignee, author identified institutions/firms those were filing patents in the field of biosensors. It is observed that 11 patents were individual patents and the rest 139 patents were filed by 91 institutions/firms. Of these 139 patents, 15 patents came from academic institutions, 4 from research institutions and 12 from governmental departments.

An analysis of the growth of new companies during different periods indicates that up to 1988 only four companies have filed 7 patents, while during 1989-91 as many as 19 new companies joined the race and this number grew to 45 during 1992-94. Further analysis of the data indicates that most of the companies active in filing patents were from USA except Matsushita Electric Industrial Co Ltd from Japan and Pharmacia Biosensor AB from Sweden. Table 3 lists institutions/companies which have filed 3 or more patents during 1983-95.

Analysis of the data for the areas in which these companies were filing patents indicates that Matsushita Electric Industrial Co Ltd concentrated on method of making biosensors and their applications in measuring the concentration of substrates in a liquid sample, while Pharmacia Biosensor AB primarily concentrated on sensing surfaces, which could be used in biosensor systems. This indicates that the two companies did not have any direct competition among themselves.

Niche Areas of Patenting Activity

The data obtained for 150 patents filed in USA during 1983-95 were analyzed to iden-
Table 4 - Niche areas of the patenting activity in biosensors

<table>
<thead>
<tr>
<th>Sub-field/area</th>
<th>USA</th>
<th>Other countries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme membrane biosensors</td>
<td>14</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>Electrochemical biosensors</td>
<td>10</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Immunological biosensors</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Thin film biosensors</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Glucose biosensors</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Solid state ion/oxygen sensors</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Force detecting sensors</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Amperometric sensors</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Identify the niche areas in which the patents were being filed. The areas in which relatively large number of patents are being filed have been considered as the niche areas. In Table 4, author has listed the niche areas along with the number of patents from USA and other countries. Based on this, it is observed that enzyme membrane biosensors and electrochemical biosensors are the niche areas. Unitika Ltd and Terumo Kabushiki Kaisha, both in Japan, have been active in the area of enzyme membrane biosensors. However, such an effort from companies in other countries is yet to be visible. In the field of electrochemical biosensors, Hitachi Ltd from Japan is active, while in USA the major activity in the field is in the academic and governmental research institutions.

Findings

1. The number of patents in biosensors has increased both in absolute terms as well as in percentage of the total number of patents, which indicates that this is an area of growing importance in scientific research.

2. USA and Japan are the leading countries filing patents in biosensors.

3. Most of the patents are owned by industrial firms.

4. The niche area on the basis of patenting activity are enzyme membrane biosensors followed by electrochemical biosensors.

Acknowledgement

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References


Appendix 1 - Biosensor patents filed in USA during 1983-95

2. Electrochemical sensor having an immobilized enzyme membrane, (Hitachi, Ltd., Japan) US Pat No. 4579642, 1 April 1986.
3. Implantable gas-containing biosensor and method for measuring an analyte such as glucose (Children’s Hospital Medical Centre, USA) US Pat No. 4680268, 14 July 1987.
15. Miniaturized oxygen electric and miniaturized biosensor and production process thereof (Individually owned patent, Japan) US Pat No. 4975175, 4 Dec 1990.
17. Turbulent shear force microsensor (Massachusetts Institute of Technology, USA) US Pat No. 4908509, 23 March 1990.
18. Traction and reaction force microsensor (Massachusetts Institute of Technology, USA) US Pat No. 4908509, 13 March 1990.
19 Differential homogeneous immunosensor device (Olmicron corporation, USA) US Pat No. 4916075, 10 April 1990

20 Method for making thin films orthogonal microsensor for air flow (Honeywell Inc, USA) US Pat No. 4895616, 23 Jan 1990.

21 Thin films orthogonal microsensor for air flow and method (Honeywell Inc., USA) US Pat No. 4914712, 3 April 1990.

22 Enzyme sensor (Terumō kabushiki Kaisha, Japan) US Pat No. 4927516, 22 May 1990.

23 Enzyme sensor using immobilized glucokinase (Unitika Ltd, Japan) US Pat No. 4900423, 13 Feb 1990.

24 Biosensor and method for making the same (Matsushita electric industrial co. Ltd, Japan) US Pat No. 4897173, 30 Jan 1990.

25 Biosensor device provided with agitator (NEC Corporation, Japan) US Pat No. 4956149, 11 Sept 1990.


27 Methods of operating enzyme electrode sensors (Imperial Chemical Industries Plc, UK) US Pat No. 4935105, 19 June 1990.

28 Acoustic wave microsensors for measuring fluid flow (Individually Owned patent, USA) US Pat No. 5003822, 2 April 1991.


32 Biosensor electron excitation (Boehringer Mannheim Corporation, USA) US Pat No. 4999582

33 Method for detecting meat freshness using a biosensor (Taiyo Fishery Co. Ltd, Japan) US Pat No. 4985125

34 Adapter assembly for use with a cranial biosensor (Hellige GMBH, Germany) US Pat No. 4993425, 19 Feb 1991.

35 Method for identifying individuals from analysis of elemental shapes derived from biosensor data (Individually owned patent, USA) US Pat No. 5163094, 10 Nov 1992.


Enzyme sensor and method of manufacturing the same (Individually owned patent, Japan) US Pat No. 5205920, 27 April 1993.

Process for immobilizing proteins on a support containing amino, mercapto or hydroxy groups (individually owned patent, Australia) US Pat No. 5246846, 21 Sept 1993.

Face mask impregnated with odour reducing molecular sieve material (Individually owned patent, USA) US Pat No. 5269294, 14 Dec 1993.

Preventive treatment kit against sexually transmitted disease (Individually owned patent, USA) US Pat No. 5244096, 14 Sept 1993.


Microsensor copolymer and method of manufacture (Puritan-Bennett Corporation, USA) US Pat No. 5266271, 30 Nov 1993.

Redox polymer modified electrode for the electrochemical regeneration of coenzyme (Moltech Corporation, USA) US Pat No. 5264092, 23 Nov 1993.


Oil microsensor having interdigitated electrodes with rough surfaces and methods of making and using the same (General Motors Corporation, USA) US No. 5200027, 6 April 1993.


57 Peroxidase colloidal gold oxidase biosensors for mediatorless glucose determination (Enzyme Technology Research Group Inc., USA) US Pat No. 5225064, 6 July 1993.


59 Proton concentration sensor/modulator for sulfonated and hydroxylated polyaniline electrodes (Ohio State Research Foundation, USA) US Pat No. 5250163, 5 Aug 1993.

60 Two-terminal voltammetric microsensors (Massachusetts Institute of Technology, USA) US Pat No. 5223117, 29 June 1993.

61 Fibre optic-based regenerable biosensor (University of Tennessee Research Corporation, USA) US Pat No. 5176881, 5 Jan 1993.

62 Sensitivity and selectivity of ion channel biosensor membranes (Australian Membrane and Biotechnology Research Institute Ltd, Australia) US Pat No. 5234566, 10 Aug 1993.

63 Biosensor containing immobilized zymomonas mobilis cells for measuring glucose, fructose and sucrose (Korea Advanced Institute of Science and Technology, Korea) US Pat No. 5177012, 5 Jan 1993.

64 Optical biosensor and method of use (Bayer Aktiengesellschaft, Germany) US Pat No. 5194393, 16 March 1993.

65 Wholly microfabricated biosensors and process for the same (I-stat Corporation, USA) US Pat No. 5200051, 6 April 1993.

66 Method for the direct measurement of at least one chemical parameter of skin using a biosensor (L’ Oreal SA, France) US Pat No. 5250419, 5 Aug 1993.

67 Biosensors including lipid bilayer doped with ion channels anchored to a recording electrode by bridging molecules (Yeda Research and Development Co. Ltd., Israel) US Patent No. 5204239, 20 April 1993.


69 Method of producing microsensors with integrated signal processing (Kernforschungszentrum Karlsruhe GMBH, Germany) US Pat No. 5194402, 16 March 1993.
Sensing surfaces capable of selective biomolecular interactions, to be used in biosensors systems (Pharmacia Biosensor AB, Sweden) US Pat No. 5242828, 7 Sept 1993.


Biosensor utilizing enzyme and a method for producing the same (Matsushita Electric Industrial Co. Ltd, Japan) US Pat No. 5192415, 9 March 1993.

Preparation of biosensor having a layer containing an enzyme, electron acceptor and hydrophilic polymer on an electrode system (Matsushita Electric Industrial Co. Ltd, Japan) US Pat No. 5229282, 20 July 1993.


Measuring circuit with a biosensor utilizing ion sensitive field effect transistors (Individually owned patent, Korea) US Pat No. 5309085, 3 May 1994.


Biosensor with a membrane containing biologically active material (Abbott Laboratories, USA) US Pat No. 5310469, 10 May 1994.


Enzyme electrode system (Boehringer Mannheim Corporation, Germany) US Pat No. 5288636, 22 Feb 1994.

89 Rugged O2 microsensor (Gas Research Institute, USA) US Pat No. 5282948, 1 Feb 1994.
90 Deep ultraviolet photolithographically defined ultra-thin films for selective cell adhesion and outgrowth and method of manufacturing the same and devices containing the same (Geo-Centers Inc, USA) US Pat No. 5324591, 28 June 1994.
91 Biosensor and measuring apparatus using the same (Matsushita Electric Industrial Co. Ltd, Japan) US Pat No. 5320732, 14 June 1994.
92 Amperometric sensor for single and multicomponent analysis (National University of Singapore, Singapore) US Pat No. 5312590, 17 May 1994.
94 Implantable biomedical sensor device suitable for measuring the concentration of glucose (N.V. Nederlandsche Apparatenfabrick Nedpa, Netherlands) US Pat No. 5372133, 13 Dec 1994.
95 Method of using enzyme electrode (Nova Biomedical Corporation, USA) US Pat No. 5352348, 4 Oct 1994.
97 Apparatus for emplacing viscous material in a cavity (Optex Biomedical Inc, Taiwan) US Pat No. 5342100, 30 Aug 1994.
98 Method and compositions for manufacture of chemical sensors (Puritan-Bennett Corporation, USA) US Pat No. 5326585, 5 July 1994.
100 Surface-modified electrochemical biosensor (Rutgers University, USA) US Pat No. 5286364, 15 Feb 1994.
102 Biologically mimetic synthetic ion channel transducers (Synporin Technologies Inc, USA) US Pat No. 5368712, 29 Nov 1994.
103 Microsensors for gaseous and vaporous species (Teknekrone Sensor Development Corporation, USA) US Pat No. 5304293, 19 April 1994.
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104 Apparatus for forming thin film (Geruaki Katsube, Japan) US Pat No. 5296122, 22 March 1994.


106 CDNA encoding a dopamine transporter (US Health & Human Services, USA) US Pat No. 5312734, 17 May 1994.


108 Method for the determination of the concentration of an enzyme substrate and a sensor for carrying out the method (AVL Medical Instruments Ag, Austria) US Pat No. 5340722, 23 Aug 1994.


111 Sensor for measuring the amount of a component in solution (Asulab S.A, China) US Pat No. 5378628, 3 Jan 1995.

112 Ionic reservoir at electrode surface (Australian Membrane and Biotechnology Research Institute Ltd., Australia) US Pat No. 5401278, 28 March 1995.

113 Method and apparatus using threshold techniques for generating an alarm in a biosensor (Biological Monitoring Inc., USA) US Pat No. 5469144, 21 Nov 1995.

114 Potentiometric biosensor and the method for its use (Boehringer Mannheim Corporation, USA) US Pat No. 5413690, 9 May 1995.

115 Biosensor and method for hematocrit determination (Boehringer Mannheim Corporation, USA) US Pat No. 5385846, 31 Jan 1995.

116 Process for providing a 6 ketone from morphine or an ether derivative thereof using morphine dehydrogenase (British Technology Group Limited, UK) US Pat No. 538715, 7 Feb 1995.

117 Cocaine esterase from Pseudomonas sp. NCIMB 40427 for detection of cocaine (British Technology Group Limited, UK) US Pat No. 5462868, 31 Aug 1995.


122 Methods and device for glycosylation analysis (Fisons PLC, UK) US Pat No. 5468620, 21 Nov 1995.

123 Analytical device (Fisons PLC, UK) US Pat No. 5434663, 18 July 1995.

124 Solid-state oxygen microsensor and thin structure therefor (Gas Research Institute, USA) US Pat No. 5389225, 14 Feb 1995.

125 Process for operating a solid-state oxygen microsensor (Gas Research Institute, USA) US Pat No. 5389218, 14 Feb 1995.

126 Dielectrically isolated resonant microsensors (Honeywell Inc., USA) US Pat No. 5417115, 23 May 1995.


128 Method for detecting the change in the analyte due to hemolysis in a fluid sample (I-State Corporation, USA) US Pat No. 5416026, 16 May 1995.

129 Biosensor and method of quantitative analysis using the same (Kyoto Daiichi Kagaku Co., Ltd, Japan) US Pat No. 5382346, 17 Jan 1995.


133 Fabrication process of biosensor (NEC Corporation, Japan) US Pat No. 5445020, 29 Aug 1995.

134 Electrode having a polymer coating with a redox enzyme bound thereto, the polymer coating being formed on the walls of pores extending through a porous membrane (Nederlandse Organisatie Voor Toegepaste Natuurwetenschaplij, Netherlands) US Pat No. 5422246, 6 June 1995.

135 Sensors employing interference of electromagnetic waves passing through waveguides having functionalized surfaces (Oregon Health Sciences University, USA) US Pat No. 5465151, 7 Nov 1995.

136 Matrix coating for sensing surfaces capable of selective biomolecular interactions, to be used in biosensor systems (Pharmacia Biosensor AB, Sweden) US Pat No. 5436161, 25 July 1995.

137 Optical fiber ph microsensor and method of manufacture (Puritan-Bennett Corporation, USA) US Pat No. 5378432, 3 Jan 1995.
138 Method and sensor for detecting toxic chemical exposure effects and metabolic activation of carcinogenic chemical agents (Resource Technologies Group Inc, USA) US Pat No. 5413915, 9 May 1995.


140 Biosensor using ion sensitive field effect transistor with platinum electrode (Sensor Technology Research Center for Kyungpook National University, Korea) US Pat No. 5387328, 7 Feb 1995.

141 Biosensor containing a biochemical substance immobilized on a layer of an olefinic-unsaturated, epoxyfunctional polyether (Siemens Aktiengesellschaft, Germany) US Pat No. 5389534, 14 Feb 1995.


144 Amperometric flow injection analysis biosensor for glucose based on graphite paste modified with tetracyanoquinodimethane (US Department of Commerce, USA) US Pat No. 5378332, 3 Jan 1995.

145 Chemical microsensors (University of California, USA), US Pat No. 5418058, 23 May 1995.

146 Solid state ion sensor with polyimide membrane (University of Michigan, USA) US Pat No. 5417835, 23 May 1995.

147 Immobilized enzymes for use in an electrochemical sensor (University of New Mexico, USA) US Pat No. 5476776, 19 Dec 1995.

148 Miniature implantable refillable glucose sensor and material therefor (University of New Mexico, USA) US Pat No. 5431160, 11 July 1995.

149 Methods for reducing level of interferants in biosensor systems and solutions used in these methods (Yellow Springs Instrument Company Inc, USA) US Pat No. 5429727, 4 July 1995.

150 Enzyme-electrode sensor (Victoria University of Manchester, USA) US Pat No. 5437973, 1 Aug 1995.