

Dendrimer Patent Trends 2008

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Executive Summary

The trend of increasing numbers of dendrimer patents being filed and issued continued in 2008. Major themes for Human Necessity dendrimer patents in 2008 included anti cell-adhesion dendrimer coatings, biocidal dendrimers, dendrimer composites for dental use, and new organic dendrimer compositions. Starpharma's Vivagel[®] vaginal microbical cream is on track for FDA approval in 2009. The growing backlog of unexamined dendrimer patents is causing delays in patent issuance; during 2008 the average issued patent was before the patent office for 6.5 years.

Introduction

Dendrimers are organic chemical entities with a semi-polymeric tree-like structure. The termini of the tree-like branches provide a rich source of nanoparticle surface functionality. Intermediate in size between small molecule therapeutics and macromolecular nucleic acids and proteins; they are useful as building blocks and carrier molecules. Dendrimers are small enough to fit inside a human cell. They are important in technologies such as coatings, additives, inks, golf balls, hair products, drug delivery, and gene therapy. In gene therapy dendrimers may be significantly safer than the current standard delivery technology, modified viruses.

Companies involved in dendrimers include Dendritic Nanotechnologies, Dendritech, Genisphere, Life Technologies, Nanocure, and Biostar; Starpharma in Australia; and Dow Corning Toray Silicone in Japan. Large corporations in the dendrimer area include Dow Chemical, 3M, GE, Bayer, Xerox, US Health, Schering, and L'Oreal. Major university efforts are in place at the University of California, University of Delaware, University of Michigan, Michigan Molecular Institute, and Central Michigan University.

To survey the current state of the dendrimer intellectual property, searches of issued United States patents and published United States patent applications were performed. The query "dendrimer*" was used, which will find patent references containing words such as dendrimer, dendrimers, dendrimeric and so forth. Searches were conducted covering full text US patents and applications, titles of US patents and applications, titles and abstracts of US patents and publications, titles, abstracts, and claims of US patents and applications, and claims of US patents and applications.

Discussion

Broad Dendrimer Patent Trends – All Technologies

For the broadest possible view of dendrimer patent activity, the full text of US patents and published applications were searched. Any patent document that mentions dendrimers was included in the results. Looking at the broad results indicates that dendrimer research and dendrimer patenting activity continues to grow. Figure 1 shows the number of US published applications mentioning dendrimers. Since 2005, over 1000 applications have published each year. An all-time high of 1251 US dendrimer applications were published in 2008. The number of issued patents also continues to grow, albeit at a much slower pace. During the each last three years, approximately 350 dendrimer patents have issued, as shown in Figure 2. Thus the backlog of unexamined dendrimer applications appears to be growing at a rate of roughly 800 per year.

For another view of the problem, note that a total of 2761 dendrimer patents have issued during the entire lifetime of dendrimers, starting in the 1980's. Since 2001 over 6395 dendrimer patent applications have been published. Approximately 3,600 dendrimer patents remain to be disposed of (issued or rejected). Applicants can expect to continue to enjoy long wait times between patent filing and issuance. A rough calculation shows that dendrimer patents issued during 2008 were in the hands of the US patent office for an average of six and a half years.

For dendrimer patents, in any technology area, the top 10 assignees are shown in Table 1. Combining the totals for BASF Coatings and BASF puts BASF into the overall patent lead ahead of the University of California. Interestingly, Dow, which pioneered the area, is no longer among the top 10 assignees.

Broad Dendrimer Patent Trends – Human Necessities

To focus on Food, Cosmetics, and Pharmaceuticals, the subject of the present conference, patents falling under International Patent Classification (IPC) code A, Human Necessities, were examined. The trend observed in overall dendrimer patenting is also observed in Human Necessities. As shown in Figure 3, since 1980, a total of 845 patents have issued, and a peak of 117 was reached in 2008. Published applications also continue to grow, with a total of 2419 applications published since 2001, reaching a peak of 488 in 2008.

The top assignees in Human Necessity dendrimer patents are shown in Table 2. The University of California leads the list. The leading company is US Health, followed closely by Mallinckrodt. Local companies Neose, and Novartis are on the list as well as the University of Michigan and Dow Chemical.

Broad Dendrimer Patent Trends – Human Necessities 2008

In 2008, the top two assignees in Human Necessities were the University of Michigan and the University of California. Neose, Novartis and the University of Pennsylvania were some of the local assignees on the list. The complete results are shown in Table 3.

Focused Dendrimer Patent Trends – All Technologies

For a more focused look at dendrimer patenting trends the titles, abstracts, and claims of US patents were searched for "dendrimer*." As shown in Figure 4, there were a total of 521 patents issued during the 1980-2009 period, with 58 patents issued in 2008, a record. The trend of steadily increasing patent activity, over all technologies using dendrimers, continues.

Table 4 shows the top assignees for the period 1980-2009. The organizations include the University of California, University of Michigan, Rice University, and MIT. The top patenting companies are Dow Chemical, 3M, Xerox, Biostar, Dow Corning Toray Silicon (Japan), and US Health. Bayer, Dendritech and L'Oreal round out the list.

Focused Dendrimer Patent Trends – Human Necessities

Narrowing our focus further, we see in Figure 5 the number of dendrimer patents issued in the area of Human Necessities (IPC code A). From 1980 to 2009 a total of 185 patents were issued. Twenty three patents were issued in 2008, a big increase from 2007. The overall trend of increasing dendrimer patent activity is less clear in this subset of the data. We see high variability in the numbers of patents issued, with 2002, 2006 and 2008 showing peak activity and 2003, 2004, 2005 and 2007 being down years for issued patents. So far in 2009 we are on track to exceed last year's record number of issued patents.

The top assignees in the area of Human Necessities (IPC code A) are shown in Table 5. Once again we see the University of California, University of Michigan, Rice University, and MIT. Dow, US Health, L'Oreal, Schering, 3M, and Stick Tech are the companies included in the top ten.

Focused Dendrimer Patent Trends – Human Necessities 2008

Narrowing our focus further to Human Necessity dendrimer patents issued during 2008, we find the list of top assignees in Table 6. Many of our friends are once again represented. New faces for 2008 include Advanced Cardiovascular Systems, Genecure, Shanghaimed, Sibtech, Triton Systems, and the Yokogawa Electric Corporation of Japan.

2008 – Notable Dendrimer Patents

The theme of dendrimers in coatings continued in 2008. California Institute of Technology (US 7,316,845), Advanced Cardiovascular Systems (US 7,390,407), and Yokogawa Electric (US 7,405,042) were all awarded patents for dendrimer coatings. The Cal Tech and Advanced Cardio patents were directed towards coatings for stents, devices used in wound care, and for generally preventing the adhesion of cells to coated surfaces. Yokogawa developed dendrimer-coated nanoparticles for use in capturing nucleic acids or proteins.

Genecure of Singapore was awarded US 7,320,963 for a method of delivering nucleic acids into cells. The method comprises preparing a composition of cholesterol, nucleic acid, cyclodextrin and a cationic dendrimer which is used as the nucleic acid delivery vehicle. The method is used for the delivery of anti-tumor agents to bladder cancers.

Finland's Stick Tech (US 7,354,969) developed dendrimer compositions for dental uses, including prostheses, fillings, and implants.

The use of biocidal dendrimers was patented by Triton (US 7,384,626) for use in capturing and destroying biological and chemical warfare agents. The dendrimer surface is functionalized with quaternary ammonium and N-haloamine groups.

The 3M corporation was awarded two patents (US 7,425,582 and US 7,459,146) for stabilized dispersions, comprising dendrimers, for use in drug delivery.

Finally, Central Michigan University was awarded US 7,432,239 for a new type of dendrimer. The CMU workers prepared a polyethylene glycol (PEG) polyamidoamine (PAMAM) composite dendrimer. The resulting dendrimer has different solubility properties from previous compositions.

Commercially, the most important dendrimer pharma news in 2008 is Starpharma's continued success with the anti-STD, anti-HIV cream Vivagel[®]. Vivagel[®] is a topical microbicide and FDA approval is expected in 2009. In addition, on December 17, 2008, Starpharma announced that an animal cancer model showed that Starpharma's dendrimer-doxorubicin construct achieved the same inhibition of human breast-cancer tissue as doxorubicin alone, but with markedly reduced cardiac toxicity. Multiple drug molecules are attached to the surface of the dendrimer, which has been designed to release the drug near tumors.

Conclusion

Dendrimers remain a hot area of research and patenting activity. After nearly thirty years of dendrimer research, the first viable commercial pharmaceutical product is nearing FDA approval. Coatings, gene delivery, and drug delivery were significant themes of 2008 dendrimer patents. These research trends will continue and the overall trend of increasing dendrimer patent activity is likely to continue in 2009. Early 2009 dendrimer patent activity indicates that we are on track for another record year.

Table 1 - United States Patents, full text search for “dendrimer*”, 1971-2009, all technologies

Count	Top Assignees
77	University of California
57	BASF Coatings AG
45	BASF AG
41	Fuji Xerox Co. Ltd.
37	Symyx Technologies Inc.
36	3M Innovative Properties Co.
32	CIBA SC Holding AG
32	Xerox Corp.
31	Eastman KODAK Co.
30	IBM

Table 2 – United States Patents, full text search for “dendrimer*”, 1971-2009, covering Human Necessities (IPC code A)

Count	Top Assignees
42	University of California
23	US Health
21	Mallinckrodt Inc.
16	Acushnet Co.
16	Immunomedics Inc.
16	Neose Technologies Inc.
16	L’Oreal
15	University of Michigan
14	Dow Chemical Co.
11	Genentech Inc.
11	Novartis AG

Table 3 – United States Patents, full text search for “dendrimer*”, 2008, covering Human Necessities (IPC Code A)

Count	Top Assignees
6	University of Michigan
5	University of California
4	Nektar Therapeutics AI Corp.
3	Invitrogen Corp.
3	Neose Technologies Inc.
3	University of Pennsylvania
2	3M Innovative Properties Co.
2	Compugen Ltd.
2	Mallinckrodt Inc.
2	Nitromed Inc.
2	Nitto Denko Co.
2	Novartis AG
2	Novartis Vaccines & Diagnostics
2	Nymox Pharmaceutical Corp.
2	Stick Tech OY
2	Oklahoma State University
2	Pittsburgh University
2	US Health
2	Vical Inc.
2	Wyeth Corp.

Table 4 – United States Patents, search of titles, abstracts, and claims for “dendrimer*”, 1971-2009, all technologies

Count	Top Assignees
24	Dow Chemical Co.
24	University of California
13	3M Innovative Properties Co.
10	Xerox Corp.
9	Michigan Molecular Institute
8	Biostar Inc.
8	Dow Corning Toray Silicon
8	US Health
7	Bayer AG
7	Dendritech Inc.
7	L’Oreal

Table 5 – United States Patents, search of titles, abstracts, and claims for “dendrimer*”, 1971-2009, covering Human Necessities (IPC code A)

Count	Top Assignees
18	University of California
14	Dow Chemical
8	US Health
7	L'Oreal
5	Schering AG
5	University of Michigan
5	Rice University
4	3M Innovative Properties Co.
4	Massachusetts Institute of Technology
4	Stick Tech OY

Table 6 – United States Patents, search of titles, abstracts, and claims for “dendrimer*”, 2008, covering Human Necessities (IPC Code A)

Count	Top Assignees
2	3M Innovative Properties Co.
2	Mallinckrodt Inc.
2	University of California
2	US Health
1	Advanced Cardiovascular Systems
1	California Institute of Technology
1	Genecure Pte Ltd.
1	Georgia Tech Research Institute
1	L'Oreal
1	Pastuer Institute
1	Shanghaimed Co. Ltd.
1	Sibtech Inc.
1	Stick Tech OY
1	Triton Systems Inc.
1	Emory University
1	University of Michigan
1	Central Michigan University
1	Rice University
1	Yokogawa Electric Corp.

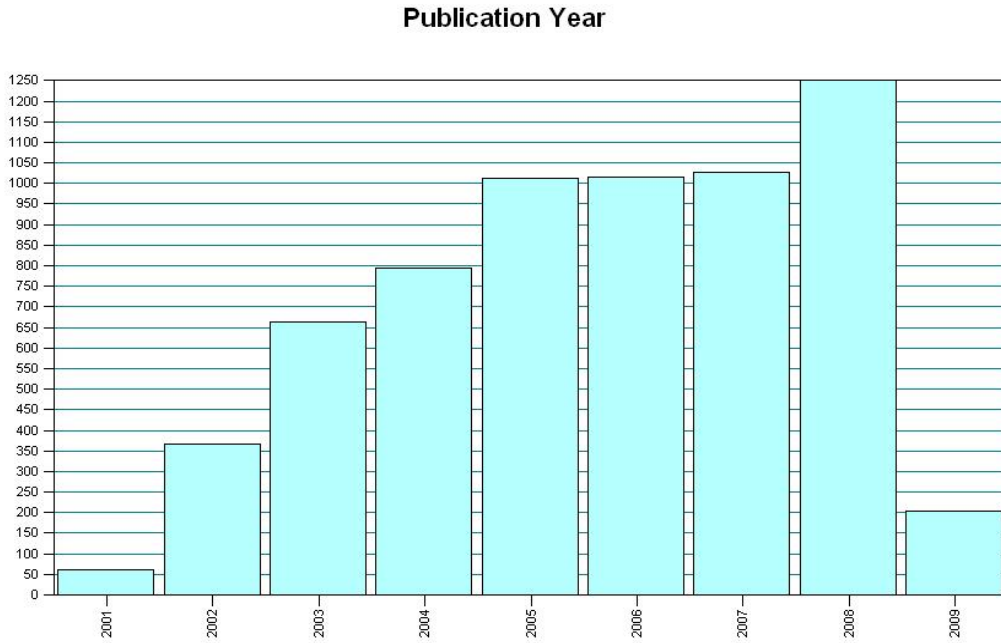


Figure 1
 United States published patent applications, full text search for “dendrimer*”, 2001-2009, all technologies, 6395 applications published, 1251 published in 2008

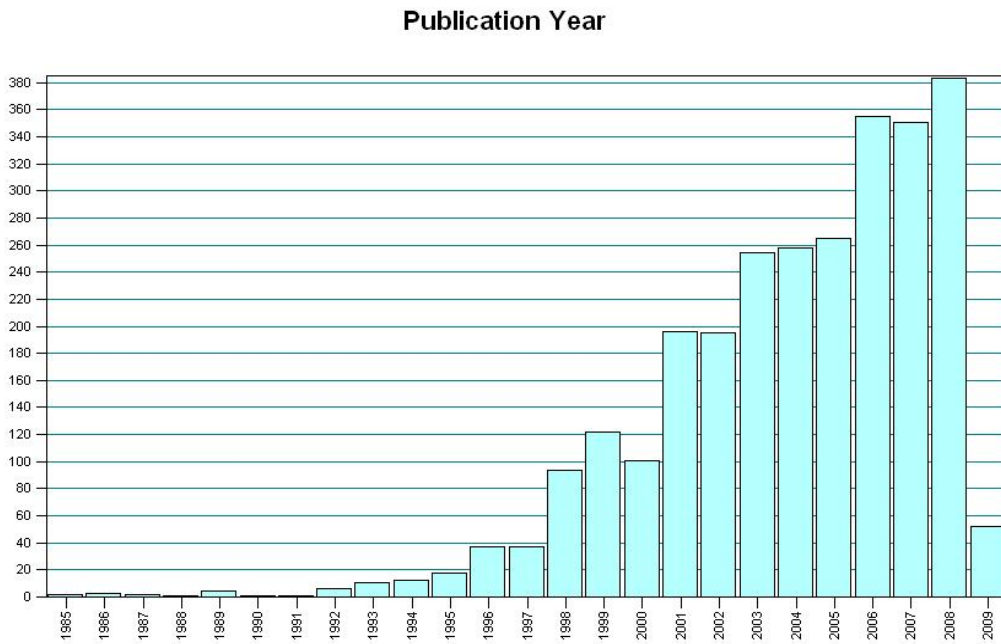


Figure 2
 United States Patents, full text search for “dendrimer*”, 1980-2009, all technologies, US 2761 total patents, 384 issued in 2008

Publication Year

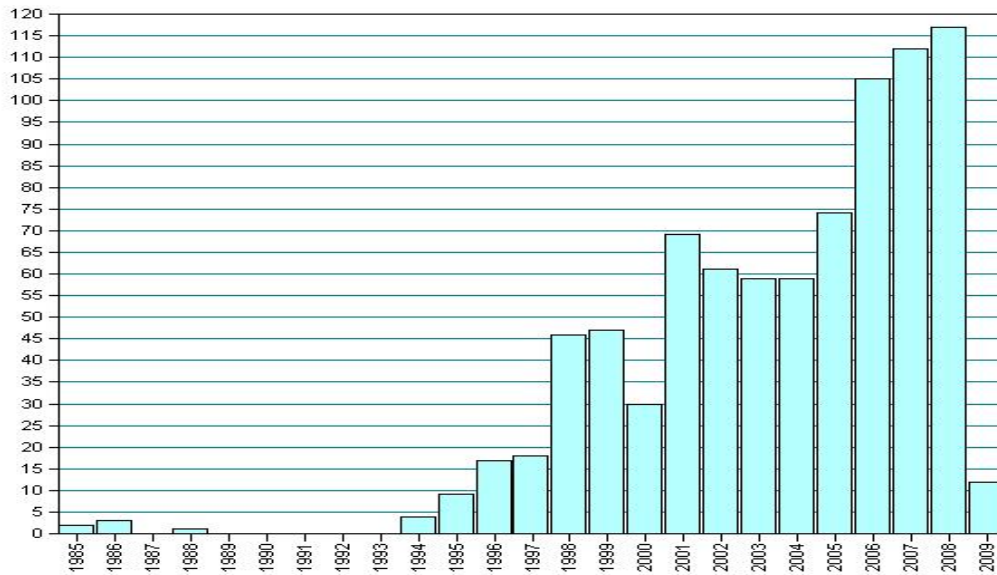


Figure 3
United States patents, full text search for “dendrimer*”, 1980-2009, covering Human Necessities (IPC code A), 845 total patents, 117 issued in 2008

Publication Year

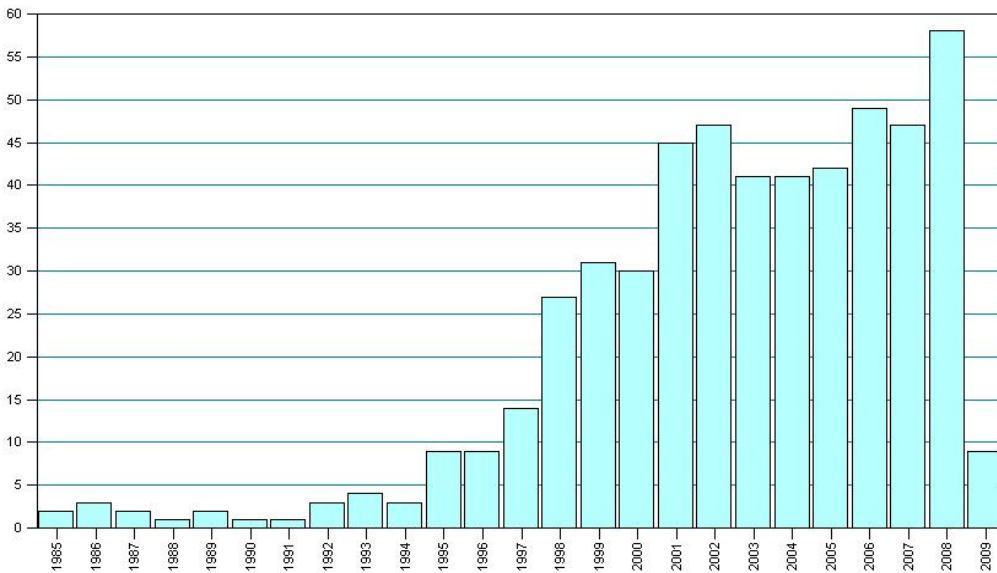


Figure 4
United States patents, search of title, abstract, and claims for “dendrimer*”, 1980-2009, all technologies, 521 total patents, 58 issued in 2008

Publication Year

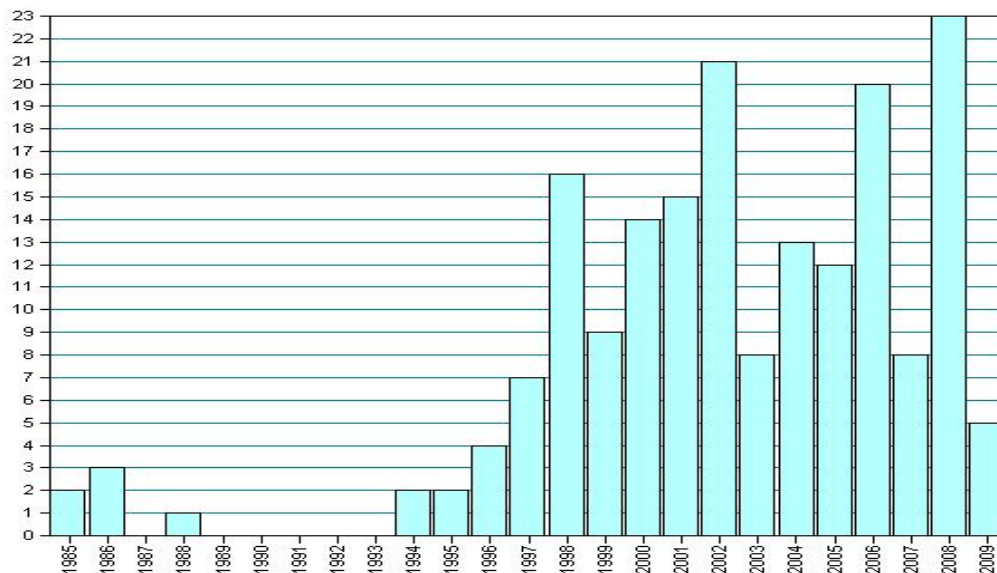


Figure 5
United States patents, search of titles, abstracts, and claims for “dendrimer*”, 1980-2009, covering Human Necessities (IPC code A), 185 total patents, 23 issued in 2008