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Scientometric Analysis of Nanotechnology in MEDLINE

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ABSTRACT

Introduction: Nanotechnology is the study and application of extremely small materials and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. An alternative method for considering the trend of research activities in countries is quantitative analysis of scientific output. The objective of current study is to analyze and visualize the trend of scientific output in the field of nanotechnology in MEDLINE during a period of 10 years 2001-2010. ***Methods:*** The extraction of data was restricted to the data set that was indexed under the major heading of "nanotechnology" in MEDLINE through years 2001 – 2010. Data on patent applications was obtained from WIPO Statistics Database. Database of Science Citation Index Expanded (SCIE) was selected from Web of Science to obtain publications indexed under the topic of nanotechnology. ***Results:*** Analysis of data showed that the research activities in the field of nanotechnology have been increased steadily through the period of study. The number of publications in 2010 was ~ 84 times greater than those in 2001. English language consisting of 98% of total publications was the most dominant language of publications. Based on Bradford's scattering's law the journal of "*Nanoscience and Nanotechnology"* distributing 12.8% of total publications was the most prolific journal. ***Conclusion:*** The USA contributing 39% of world's publications in the field was the most productive country followed by China (10%), Germany (6%), Japan (6%), Korea (5%) and UK (4%). The majority of world's publications (70%) were produced by these six countries. The tremendous growth of publications was simultaneously with the rapid growth of patent application in the field of Micro-structural and nano-technology in WIPO.

Introduction

Nanotechnology is the study and application of extremely small materials and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Nanotechnology is not just a new field of science and engineering, but a new way of looking at any studying (US National Nanotechnology Initiative 2011). According to Nanotechnology Investing (2011), nanotechnology is a materials science that has the following characteristics:

1. Research and development at molecular or atomic levels, with lengths ranging between about 1 to 100 nanometers.
2. Creation and use of systems, devices, and structures that have special functions or properties because of their small size.
3. Ability to control or manipulate matter on a molecular or atomic scale.

Within the last decade, nanotechnology has changed and influenced considerably every field of science. Nowadays the nanotechnology has become a powerful technique in medicine and it is very practical in improving nanoparticles for diagnostic and screening points, artificial receptors, DNA sequencing using nanopores, Development of unique drug delivery systems, gene therapy applications and the enablement of tissue engineering (Emerich and Thanos 2003).

> "*There are a number of potential applications for medical nanotechnology, and in its early phases, many people were quite excited about the huge changes which could occur in the medical world with the assistance of medical technology. Because*

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nanotechnology operates on such a small scale, it offers the opportunity to create precisely targeted surgical instruments, drug delivery systems, and implants. Nanobots, for example, could be used to perform a non-invasive medical imaging study inside the body, or to perform surgical procedures. Nanomaterials can also be implanted into the body; for example, someone with a badly damaged bone or joint could be treated with nanoparticles which would promote new growth, regrowing the damaged tissue. Medical nanotechnology also makes cell repair on a molecular level possible, and provides a number of opportunities for medication administration. Drugs developed through nanotechnology could directly penetrate cells for example, or nanoparticles could be designed to target cancer cells, delivering medication or providing a focal point for radiation. Medical nanotechnology can also be used to make biosensors which can be implanted into patients for monitoring, along with medical devices which are designed to be permanently implanted such as pacemakers" (Smith 2011).

Nowadays, nanotechnologies are fully inserted in the paths of "creative destructions" generated by technical knowledge (Bozeman *et al*. 2007). In this paper, we attempt to visualize the scientific profiles of leading countries in the field of medical nanotechnology during the last decade (2001-2010). To achieve the aim, we selected the database of MEDLINE for obtaining data about scientific publications in the field of nanotechnology. Scientific publication can mirror the scientific activities in different disciplines in countries.

Materials and methods

PubMed was used to extract the reliable literature for nanotechnology by using the term of nanotechnology as a major main heading through 2001-2010. We restricted our search to MEDLINE by selecting MEDLINE from subsets' menu. MEDLINE is a biomedical bibliographic database that was developed by the National Center for Biotechnology Information (NCBI) at the National Library of Medicine (NLM), located at the National Institutes of Health (NIH). Data about patents application was obtained from WIPO Statistics Database. Database of Science Citation Index Expanded (SCIE) was selected from Web of Science to obtain publications indexed under the topic of nanotechnology.

Results

The number of scientific output in the field of nanotechnology in MEDLINE during the last decade (2001-2010) is shown in Fig. 1. It indicates that the number of scientific publications has been increased steadily over the time. Only a small decline of 10% appeared in 2008 compared to 2007.

A total number of 11,991 scientific documents was published and indexed in MEDLINE. The yearly average number of documents published was 1,199. The highest numbers of publications (2,072) were published in 2010.This is an indicative that an upward trend in the number of publications was appeared during the period of study; in spite of a slight decline in 2008. Through the last three years of study (2008-2010) was the most proliferation years under study; so that 48% of total publications was published during these years.

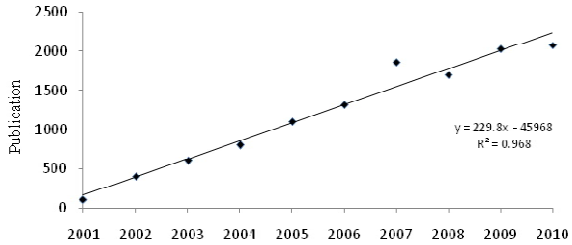

Fig. 1. Number of publications in the field of nanotechnology in MEDLINE 2001-2010.

With a look at the number of scientific publications in the field of nanotechnology in the Science Citation Index Expanded through 2001-2010 we find that there was a steady growth during the period of study in this database, too (Fig. 2).

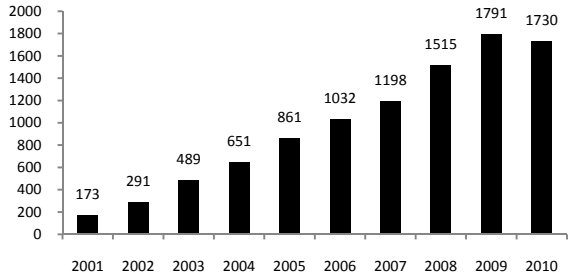

Fig. 2. Number of publications in the field of nanotechnology in SCIE 2001-2010.

Patent applications in the field of nanotechnology in WIPO can show the world's attitude towards this new area of science. Figure 3 indicates that the number of patent application in the field of Micro-structural and non-technology has been increased exponential since 2006. The number of patent applications in 2010 was 74% greater than that in 2006.

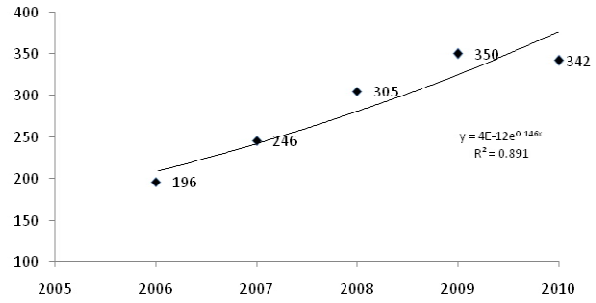

Fig. 3. Number of patent applications in the field of Micro-structural and nanotechnology from 2006 to 2010 (WIPO 2011).

The origin country of publications is shown in Figure 4. The figure is restricted to the countries that their world percentage sharing was equal or greater than 1%.

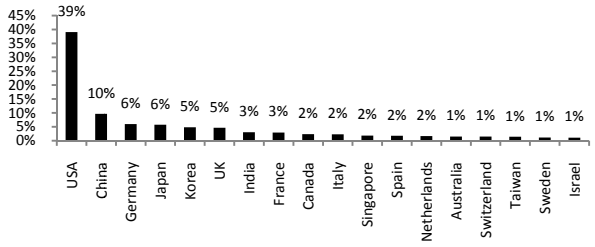

Fig. 4. Origin country of publications in the field of nanotechnology in MEDLINE 2001-2010.

Figure 4 shows eighteen top countries according to their scientific publications share over the period of 2001-2010. Only eight countries had a share of 3% or more. The dominant country was the United States. USA produced 39% of scientific world's output in the field. Other more productive countries are China sharing 10% of world scientific publications, Germany 6%, Japan 6%, Korea 5%, UK 5%, India 3%, and France 3%. Below these leading countries, ten countries each produced between 1% and 3% of the world scientific output as measured.

As shown in Table 1, English consisting of 98.2% of total publication was the most dominant language of publications in the field of nanotechnology in MEDLINE through the period of study.

A total number of 11,991 scientific papers in the field of nanotechnology were published in 39 different formats. Journal articles consisting of 41% of total publication type was the most frequent format of publications. The following formats are Research Support, Non-U.S. Gov't (26%), Research Support, U.S. Gov't, Non-P.H.S. (10%), Review (6%), Evaluation Studies (4%) and Research Support, N.I.H., Extramural (4%).

Table 1. Frequency of publication languages in MEDLINE 2001-2010

Language	Frequency	Percent
English	11775	98.20%
Chinese	88	0.73%
Japanese	43	0.36%
Russian	23	0.19%
German	15	0.13%
French	14	0.12%
Italian	7	0.06%
Spanish	5	0.04%
Korean	4	0.03%
Polish	4	0.03%
Ukrainian	4	0.03%
Rumanian	3	0.03%
Hungarian	2	0.02%
Czech	1	0.01%
Dutch	1	0.01%
Lithuanian	1	0.01%
Swedish	1	0.01%
Total	**11,991**	**100.00%**

Table 2. Frequency of publication type of documents in the field of nanotechnology in MEDLINE 2001-2010

Rank	Publication Type	Frequency	Percent
1	Journal Article	11109	41%
2	Research Support, Non-U.S. Gov't	7022	26%
3	Research Support, U.S. Gov't, Non-P.H.S.	2726	10%
4	Review	1694	6%
5	Evaluation Studies	1029	4%
6	Research Support, N.I.H., Extramural	989	4%
7	Comparative Study	448	2%
8	News	346	1%
9	Research Support, U.S. Gov't, P.H.S.	276	1%
10	Editorial	248	1%
11	Comment	232	1%
12	English Abstract	159	1%
13	Letter	146	1%
14	Validation Studies	119	0%
15	Introductory Journal Article	85	0%
16	Congresses	80	0%
17	Historical Article	46	0%
18	In Vitro	46	0%
19	Research Support, N.I.H., Intramural	31	0%
20	Overall	22	0%
21	Interview	21	0%
22	Biography	10	0%
23	Portraits	8	0%
24	Case Reports	5	0%
25	Lectures	4	0%
26	Video-Audio Media	4	0%
27	Randomized Controlled Trial	3	0%
28	Retracted Publication	3	0%
29	Bibliography	2	0%
30	Clinical Trial	2	0%
31	Newspaper Article	2	0%
32	Technical Report	2	0%
33	Webcasts	2	0%
34	Consensus Development Conference	1	0%
35	Consensus Development Conference, NIH	1	0%
36	Controlled Clinical Trial	1	0%
37	Festschrift	1	0%
38	Guideline	1	0%
39	Research Support, American Recovery and Reinvestment Act	1	0%
Total		**26,927**	**100%**

A total number of 11,991 papers in the field of nanotechnology were published in 906 journals. Table 3 is restricted to the journals name that their frequency was equal or greater than 50 times during the period of time.

Table 3. Frequency of Journals publishing scientific papers in the field of nanotechnology in MEDLINE 2001-2010

Rank	Journal Name (abbreviation)	Frequency	Percent
1	J Nanosci Nanotechnol	1537	12.8%
2	Nano Lett	1190	9.9%
3	Small	718	6.0%
4	Nat Nanotechnol	514	4.3%
5	ACS Nano	467	3.9%
6	Nanotechnology	454	3.8%
7	Opt Express	284	2.4%
8	Nat Mater	254	2.1%
9	J Am Chem Soc	248	2.1%
10	Langmuir	242	2.0%
11	Nanomedicine (Lond)	184	1.5%
12	Anal Chem	173	1.4%
13	Biosens Bioelectron	146	1.2%
14	Angew ChemInt Ed Engl	119	1.0%
15	Adv Mater	104	0.9%
16	Proc Natl Acad Sci U S A	98	0.8%
17	Science	91	0.8%
18	Lab Chip	90	0.8%
19	Nature	85	0.7%
20	Biomaterials	80	0.7%
21	Int J Pharm	76	0.6%
22	Phys Chem Chem Phys	75	0.6%
23	ACS Appl Mater Interfaces	72	0.6%
24	Chem Commun (Camb)	72	0.6%
25	J Control Release	71	0.6%
26	Methods Mol Biol	71	0.6%
27	J Phys Chem B	70	0.6%
28	Nanomedicine	69	0.6%
29	Anal Bioanal Chem	67	0.6%
30	Int J Nanomedicine	61	0.5%
31	Biomacromolecules	59	0.5%
32	Ann N Y Acad Sci	56	0.5%
33	Biophys J	56	0.5%
34	J Colloid Interface Sci	56	0.5%
35	Environ Sci Technol	54	0.5%
36	Pharm Res	53	0.4%
37	IEEE Trans Nanobioscience	50	0.4%
38	Rev SciInstrum	50	0.4%

Table 3 indicates that the most productive journals are four. 33% of world's share was published in these journals. The 10 top journals in table shared ~ 50% of total publications through the period of study.

As shown in Table 4, a total number of 6,597 (55%) of total journals came from the USA. It is considerable that more than 80% of total journals came from English spoken language countries (USA 55%, England 25.2%, New Zealand 0.6%and Canada 0.2%). Germany contributing of 10.3% of publications place is the most productive non-English country that is located at the third place of ranking order.

Based on Bradford's law, four journals (J Nanosci Nanotechnol, Nano Lett, Small, Nat Nanotechnol and ACS Nano) are located in the first zone which contributed 33% (3,959 papers) of total publication through the period of study. In the second zone there are 29 journals which published 3,994 papers and in the third zone there are 873 journals which distributed 4,038 papers (Table 5).

Table 4. Frequency of publications place of journals

Rank	Publication Place	Frequency	Percent
1	United States	6597	55.0%
2	England	3019	25.2%
3	Germany	1235	10.3%
4	Netherlands	582	4.9%
5	China	97	0.8%
6	Japan	79	0.7%
7	New Zealand	67	0.6%
8	United Arab Emirates	58	0.5%
9	France	38	0.3%
10	Switzerland	33	0.3%
11	Denmark	22	0.2%
12	Italy	22	0.2%
13	Russia (Federation)	22	0.2%
14	Canada	18	0.2%
15	India	14	0.1%
16	Australia	12	0.1%
17	Greece	9	0.1%
18	Spain	8	0.1%
19	Korea (South)	7	0.1%
20	Scotland	7	0.1%
21	Poland	6	0.1%
22	Ukraine	6	0.1%
23	Austria	4	0.0%
24	Ireland	4	0.0%
25	Romania	4	0.0%
26	Belgium	3	0.0%
27	Wales	3	0.0%
28	Czech Republic	2	0.0%
29	Hungary	2	0.0%
30	Russia	2	0.0%
31	Brazil	1	0.0%
32	Finland	1	0.0%
33	Israel	1	0.0%
34	Korea	1	0.0%
35	Lithuania	1	0.0%
36	Singapore	1	0.0%
37	South Africa	1	0.0%
38	Sweden	1	0.0%
39	Thailand	1	0.0%
Total		**11,991**	**100.0%**

Table 5. Bradford's distributions of articles over different journals

Zones	Number of journals	Number of articles
First	4	3,959
Second	29	3,994
Third	873	4,038
Total	**906**	**11,991**

The fraction of Iranian institutes contributing the literature of science in the MEDLINE is shown in Table 6. As shown in the table the Iranian institutes contributed only 0.3% of total publications in MEDLINE through the period of study.

Table 6. Publications distributed by Iranian institutes

Rank	Institutes names	Publication
1	Tarbiat Modares University	5
2	Isfahan University of Technology	3
3	University of Tehran	3
4	Islamic Azad University, Tehran	2
5	University of Tabriz	2
6	Azad University of Tonekabon	2
7	Sharif University of Technology	2
8	Amirkabir University	2
9	Shiraz University	1
10	Azad University of Medical Sciences, Tehran	1
11	Mashhad University of Medical Sciences	1
12	Payame Noor University(PNU), Isfahan	1
13	University of Isfahan	1
14	University of Kurdistan	1
15	Tehran University of Medical Sciences	1
16	Iran University of Science & Technology (IUST)	1
17	Isfahan University of Medical Sciences	1
18	Shahid Beheshti University	1
19	National Institute of Genetic Engineering and Biotechnology (NIGEB)	1
20	University of Mazandaran	1
Total		**33**

As shown in Table 7, the most majority of papers from Iran were published in journals from England (39%), Netherlands (27%) and USA (21%); whereas the most majority of papers from Turkey were published in journals from USA (55%) and England (30%).

Table 7. Publication place of papers originated from Iran and Turkey

Publication place	Turkish papers		Iranian papers	
	Frequency	Percent	Frequency	Percent
USA	18	55%	7	21%
England	10	30%	14	39%
Netherlands	3	9%	9	27%
Germany	1	3%	2	6%
New Zealand	1	3%	2	6%
Total	**33**	**100%**	**33**	**100%**

Discussion and conclusion

Extracting the literature of science in the field of nanotechnology using database of MEDLINE during a period of ten years from 2001 to 2010 resulted in 11,991 scientific documents from 290 journals. The ranking of journals and their respective contributions based on Bradford's Law of journals Scattering indicated three zones, each producing approximately one third of the distributed papers over time. Four journals were in the first zone, 21 in the second zone, and 873 journals were in the third zone.

The United States of America was the predominant country sharing the nanotechnology literature (55% of the journals and 39% distributed papers). English language consisting of 98.2% of total publications was the most common language. The predominate language of documents in English should not come as a surprise, because more than 82% of total publications in this study came from English spoken countries such as USA, England, New Zealand, Australia and Canada; furthermore, we are aware that the growth of publications in English in MEDLINE is faster than other languages. The study of M.H. Biglu showed that the doubling time of literature of science in English is 44% faster than the total Publications in MEDLINE. Biglu in his study predicted that the percentage of publications in English in MEDLINE will reach to 97% in 2030 (Biglu and Umstätter 2007). This is an indicative that the literature of science in English is growing and going to appear more and more in American databases e.g. MEDLINE. The predominate format of publication was journals article (41%). After 2006 the study witnessed a tremendous growth of distribution of papers in the field of nanotechnology in MEDLINE as well as in the SCIE database. The increasing trend of publications in MEDLINE and in SCIE has accrued simultaneously with the growth of patent applications in the field of Micro-structural and nanotechnology in WIPO.

The fraction of Iranian institutes sharing literature of science in the field of nanotechnology in MEDLINE was 0.27% (33 papers). The contribution of Turkey in MEDLINE was the same as Iran; both two neighboring countries (Iran and Turkey) shared 0.27% (33 papers) of total publication in the field of nanotechnology in the database of MEDLINE. The Iranian papers were published in journals from 5 countries: England 39%, Netherlands 27%, United States 21%, Germany 6% and New Zealand 6%. Journal of *"Biosensors & bioelectronics"* was the most prolific journal that distributed Iranian publications. The following journals were *"Ultrasonicssonochemistry*" (9%), "*International journal of nanomedicine*" (6%), and "*Nanotechnology*" (6%). Papers originated from Turkey were published in journals from the same countries but in different distribution. Journal of "*Nanoscience and Nanotechnology*" distributing 24% of Turkish papers was the most prolific journal that distributed Turkish papers. Turkish authors tend to distribute their papers in journals from the USA and England. 55% of Turkish papers were published in American journals and 30% in journals from England; whereas the most majority of Iranian papers were published in journals from England (39%), Netherlands (27%), and USA (21%).

Ethical issues

None to be declared.

Conflict of interests

The authors declare no conflict of interests.

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