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Scientometric analysis of Nature Nanotechnology

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Introduction

Nature Nanotechnology began in 2006 under the aegis of Springer Nature. It is a multidisciplinary journal that publishes high-quality refereed papers in all aspects of nanoscience and nanotechnology. *Nature Nanotechnology* encourages the exchange of ideas between chemists, physicists, material scientists, biomedical researchers, engineers and other researchers who are active at the frontiers of this diverse and multidisciplinary field.

The journal covers research into the design, characterization and production of structures, devices and systems that involve the manipulation and control of materials and phenomena at atomic, molecular and macromolecular scales. Both bottom-up and top-down approaches and combinations of the two are covered. Coverage extends from basic research in physics, chemistry and biology, including computational work and simulations, to the development of new devices and technologies for applications in a wide range of industrial sectors (including information technology, medicine, manufacturing, high performance materials and energy and environmental technologies).

Nature Nanotechnology is a top ranked journal in the subject category of "nanoscience and nanotechnology" according to Journal Citation Reports (JCR 2016) with an impact factor (IF) of 35.267 in 2015 and ranked 15th among the 8,778 journals indexed under the Science Citation Index Expanded of Web of Science. A number of studies on single journals in various specialties have been carried out in the recent past, for example, *Water Research* (Wang *et al.*, 2010), *Scientometrics* (Chen *et al.*, 2013), *Polish Journal of Environmental Studies* (Chuang *et al.*, 2012), *Neotropical Ichthyology* (Stumpf *et al.*, 2011), *Latin American Journal of Aquatic Mammals* (Palacios *et al.*, 2014), *Science* (Liang and Rousseau, 2009), *Nature* (Arkhipov, 1999), *Journal of Information Science* (Tsay, 2011), *Journal of Molecular Graphics and Modelling* (Willett, 2007), *Malaysian Journal of Computer Science* (Zainab *et al.*, 2009), *NeuroImage* (Hamadicharef, 2010), *Indian Journal of Marine Sciences* (Elango and Rajendran, 2012) and *Sadhana* (Arya, 2013).

In this study, various mapping tools such as HistCite, Sci^2 tool, intcoll.exe and CitNetExplorer are used along with traditional bibliometric techniques to draw the general outline of the first 10 years of *Nature Nanotechnology*.

Methodology

Data used in this study were obtained from the Web of Science core collection with a search of keyword "*Nature Nanotechnology*" in terms of a publication source name. The data were obtained on June 29, 2016. Documents published in the first 10 years (from 2006 to 2015) of *Nature Nanotechnology* are analyzed through the parameters of document types, publication output, authorship, impact factor, most productive authors, institutes and countries and the most-frequently cited articles. The data were analyzed with HistCite. Further, mapping tools such as intcoll.exe, Sci^2 tool and CitNetExplorer tool were used to study the collaboration behavior and citation network.

HistCite calculates the total local citation score (TLCS) and the total global citation score (TGCS). TLCS is the number of times a publication cited by other publications in the current data set which means the citation scored among the collection of 2060 publications of *Nature Nanotechnology*. TGCS is the number of times a publication cited by other publications in WoS.

Results and discussion

Yearly output

Table I presents the annual number of publications, number of authors per publication, share of single authored publications, percentage of citable documents and number of cited references per publication. Only in the founding year, the number of publications is very low because the journal was first published in October 2006. From 2007 onwards, the number of publications rose to more than 200. Similarly, the number of authors per publication also increased from 3.44 in the year 2006 to 5.16 in the year 2015 with an average of 4.57. The percentage of single authored publications is decreasing. The share of citable publications (articles and reviews) also increased with 55 per cent of total publications during the first 10 years. In total, 21 references were cited per publication in 2006, comparing to 27 references per publication in 2015.

Citation profile

Table II presents the information on yearly changes in citations per paper. The publications of 2008 had the highest value in the three indicators: CPP considering all publications, cited publications and non-cited publications. Recent years, 2014 and 2015, had the highest percentage of non-cited publications; this is negligible as the circulation period is very short, whereas the year 2011 had the lowest percentage of non-cited publications. It can be attributed that there was a higher percentage of citable publications and the number of publications was low in 2011 after the journal's first issue in 2006.

Nature Nanotechnology is listed under the Web of Science subject category of nanoscience and nanotechnology. Figure 1 shows the trends of IF of *Nature Nanotechnology* from 2006 to 2015. The

Table I.
Annual characteristics of Nature Nanotechnology*, 2006-2015*

Year	No. of Pubs.	AU	AU/Pub.	SA (%)	CP (%)	NR/Pub.
2006	55	189	3.44	23 (41.82)	43.64	21.38
2007	207	713	3.44	73 (35.27)	45.89	19.56
2008	205	732	3.57	71 (34.63)	46.83	19.30
2009	233	904	3.88	73 (31.33)	54.08	20.96
2010	223	995	4.46	42 (18.83)	58.30	23.13
2011	185	1,005	5.43	42 (22.70)	63.24	28.23
2012	197	971	4.93	43 (21.83)	61.42	25.06
2013	244	1,225	5.02	70 (28.69)	53.28	24.61
2014	259	1,388	5.36	67 (25.87)	54.83	24.73
2015	252	1,300	5.16	64 (25.40)	60.32	26.96
Average			4.57	27.57	55	24

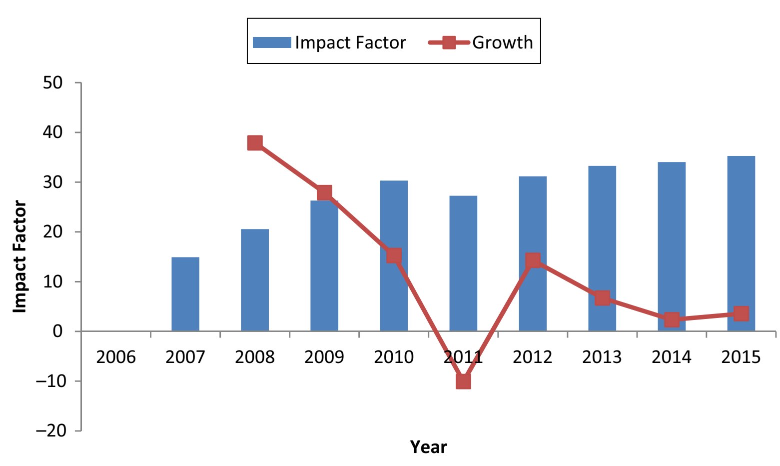
Notes: Pubs. = publications; AU = number of authors; AU/Pub. = number of authors per publication; SA = number of single authored publications; CP = citable publications; NR = number of cited references; NR/Pub. = number of cited references per publication

Table II.
Citation impact of Nature Nanotechnology*, 2006-2015*

Year	CPP/Pubs.	CPP/CP	CPP/non-CP	Non-cited (%)
2006	147.89	315	18.52	7.27
2007	128.84	263.71	14.44	11.59
2008	182.85	371.10	17.05	13.66
2009	108.04	186.27	15.92	12.88
2010	119.20	198.56	8.27	9.87
2011	119.38	182.40	10.94	6.49
2012	88.17	140.21	5.32	7.61
2013	47.46	84.35	5.40	14.34
2014	31.55	55.34	2.68	20.85
2015	11.09	17.57	1.23	26.98
Average	90	156	9.41	14.17

Notes: CPP = citations per paper; Pubs. = publications; CP = citable publications

Figure 1. *Trend and growth of impact factor*



journal got its first IF in 2007 with 14.917, and, after that, the IF value increased except in the year 2011 where there was a slight dip. The highest growth in IF has been observed in 2008, and, thereafter, there was declining trend in the growth. It is observed that there has been a 136 per cent increase in IF in 2015 over 2007. It has maintained the 15th rank in terms of IF among the journals indexed under Web of Science expanded from 2014.

Distribution of publications by document type

Nature Nanotechnology published 2060 papers during the first 10 years (2006-2015). Almost 50 per cent of papers were published as articles, whereas the remaining 50 per cent by other document types such as news items, editorials, reviews, etc. In terms of quality, reviews had the highest citations per paper (400.15) followed by articles (140.55); both are only citable documents published in this high impact journal. Other types of documents had low citation impact (Table III).

Most productive authors

Of 2060 publications, 95 (4.6 per cent) were published by anonymous authors. Overall, 6,965 unique authors contributed to the total 1965 publications having authors names; 16 authors had more than 10 publications. Tourmey had the most number of publications in the first 10 years. Hone had the highest CPP per local citations whereas Dai received the highest CPP overall in WoS. Among the most productive authors, Rodgers (ranked fourth by number of publications) had not received any citation from publications of *Nature Nanotechnology*, and his publications received the lowest number of citations per paper. Publications by Toumey (top ranked by number of publications) received the second lowest citations per

Table III.
Document types of Nature Nanotechnology*, 2006-2015*

Document type	No. of Pubs.	(%)	TC	CPP
Article	1,063	51.60	149,285	140.44
News item	454	22.04	5,949	13.10
Editorial material	353	17.14	1,883	5.33
Review	70	3.40	28,036	400.51
Correction	67	3.25	84	1.25
Letter	53	2.57	805	15.19

Notes: Pubs. = publications; TC = total citations from time of publication to the date of access; CPP = citations per paper

paper among the most productive authors. It can be attributed that these authors published all the papers as non-citable publications such as editorial material, correction and news item.

Most productive institutes

Among the total 2060 publications, 233 (11 per cent) publications had no institution affiliation information. Overall, authors from 1,106 institutions contributed to the total 1,827 publications having affiliation information. Harvard University headed the institutions followed by MIT and Stanford University. Surprisingly, all the top institutions located in the USA except University of Cambridge and University of Oxford of UK. There is no institution ranked among the most productive eleven institutions for the remaining seven countries.

Most productive countries

Among the total 2060 publications, 272 (13 per cent) publications had no country information. Overall, authors from 47 countries contributed to the

Figure 2. *International collaboration network*

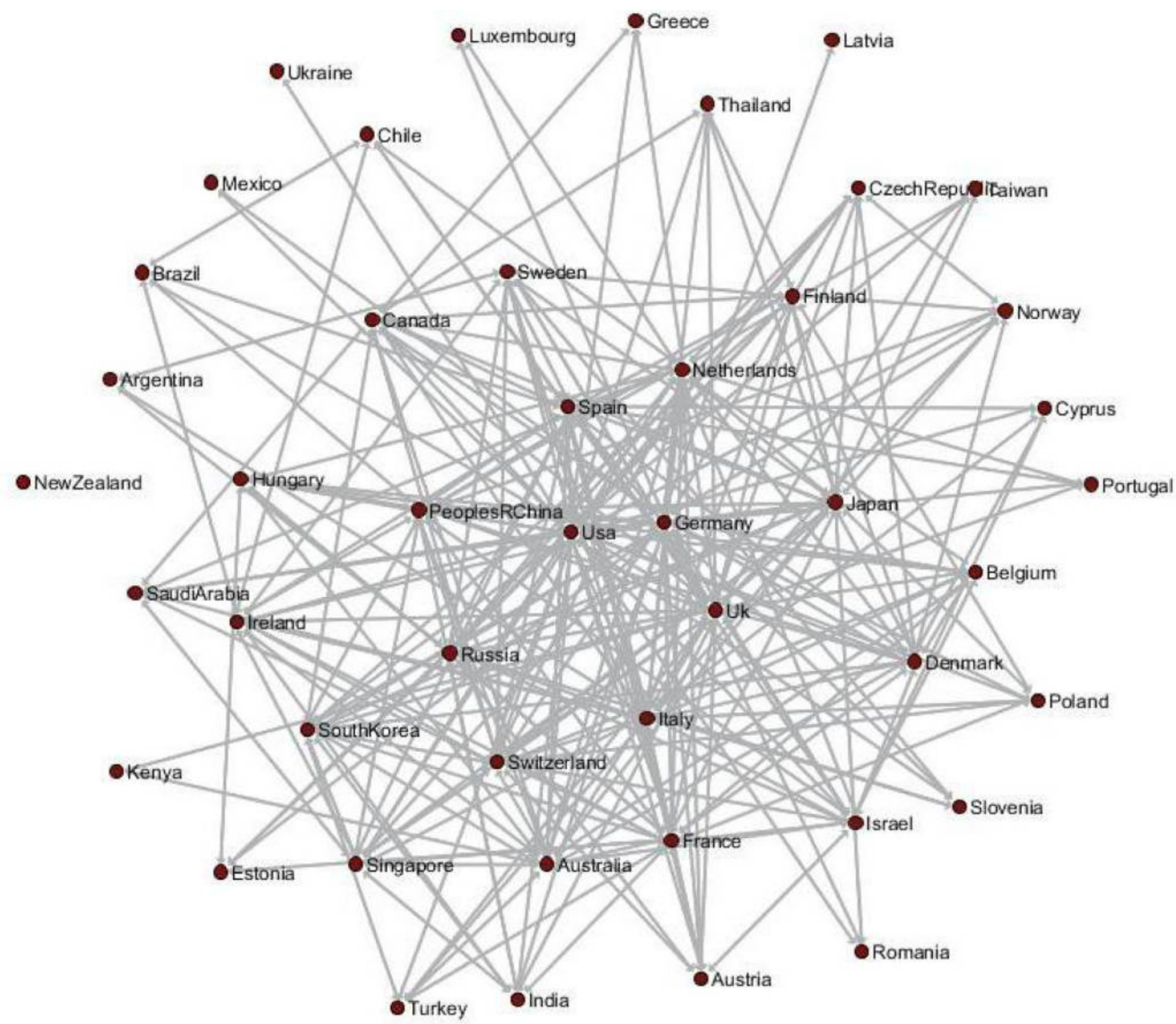
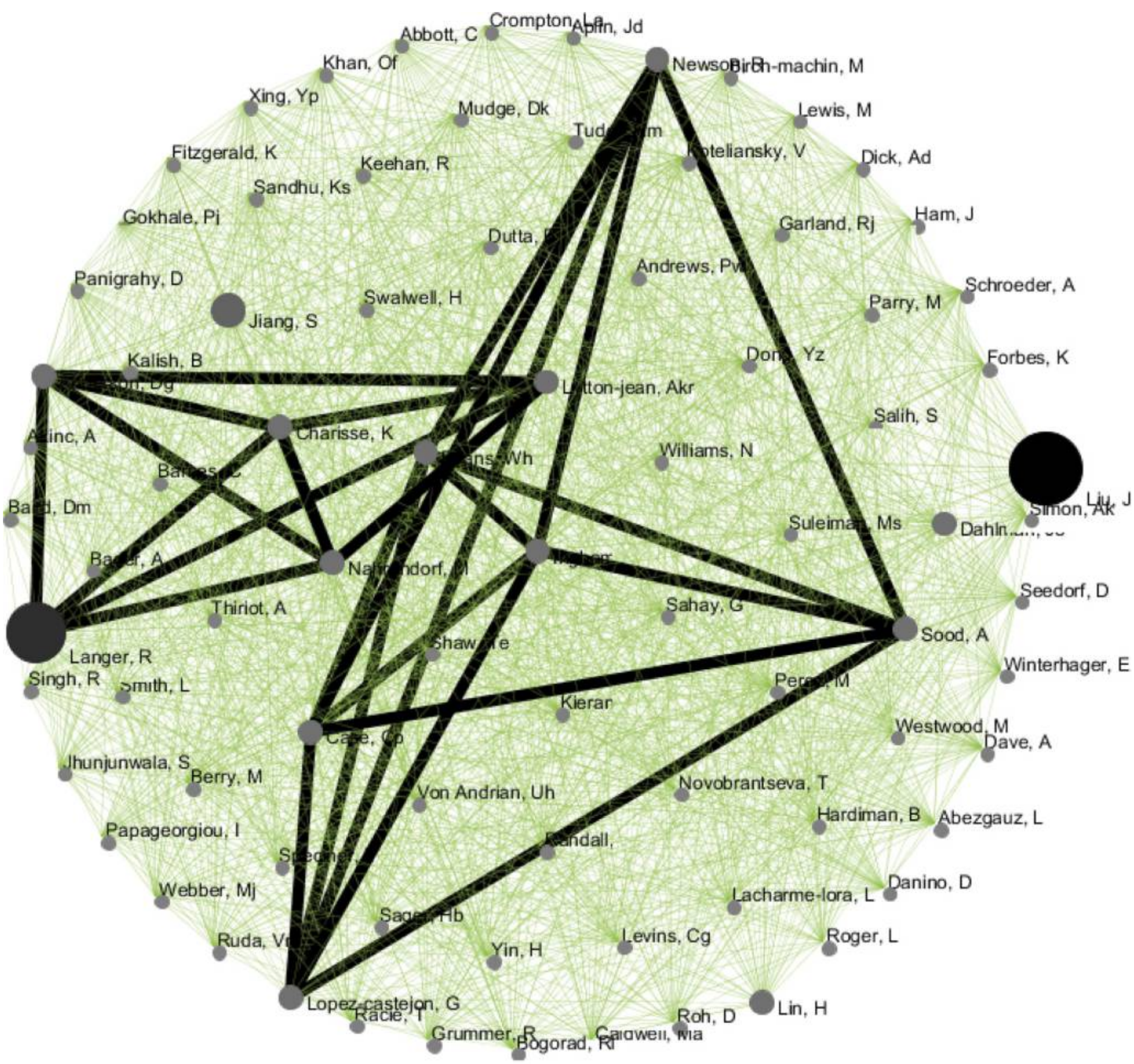


Table IV.
General properties of co-authorship network

Sl.	Item	Value
1	Nodes (Number of authors)	6,965
2	Edges (number of co-authorships)	33,459
3	Number of isolated nodes	273
4	Average degree	9.6078
5	Density	0.0041
6	Number of nodes in largest component	4,100
7	Diameter	16
8	Average shortest path	5.933

total 1,788 publications. As expected, the USA, with 976 papers came to 55 per cent (of 1,788 publications) has the largest number of publications. It is followed distantly by the UK, Germany, Japan and P. R. China. The share of publications of the ninth country (South Korea) is 3.4 per cent which is almost 15 times lower than top producing country (the USA). Surprisingly, South Korea is ranked ninth among the top contributing

Figure 3. *K-core of co-author network (k = 30)*



Notes: The size of the node denotes the number of papers and the thickness of interconnecting lines (edges) denotes the number of co-authored papers between the authors countries which is not listed among the top countries in the high impact journals (Kalita, 2016). Peoples R China ranked fourth with 102 publications which is the top second country in the scientific world (Xiang *et al.*, 2015) which shows that this country has poor contribution in the high impact journals. This result is in agreement with earlier studies (Wang *et al.*, 2010). The most productive nine countries published more than 92 per cent of total publications in *Nature Nanotechnology* in the first 10 years. From the comparison of citation scores, Switzerland topped in the TLCS per publication which is followed by South Korea, whereas it is topped in TGCS per publication followed by Japan among the most productive countries.

Map of international collaboration network is visualized in Figure 2. Each node represents one country and the interconnecting (edge) line denotes the collaboration between the countries. Countries having more number of collaborated papers with other countries are mapped at the center of the network: USA, UK, Germany, Italy, etc., which shows that the authors affiliated to the most productive countries frequently collaborated with authors from other countries, whereas countries having lesser number of collaborations with other countries are mapped in the outer layer of the network (e.g. Chile, Kenya, Brazil, etc.). Among the contributing countries, New Zealand is not integrated in the collaboration network.

Co-authorship network

Table IV shows the results of social network analysis of co-authorship network among the contributing authors of *Nature Nanotechnology* during the ten year period. There are 273 isolated nodes which means that these nodes do not have collaborative relations with other nodes during the study period. The average shortest path between a pair of nodes of the network is 5.93. Density refers to the ratio between the number of edges and the number of possible edges in the graph which can vary from a minimum of 0 to a maximum of 1. It is observed from Table IV that 0.41 per cent of possible edges (co-authorships) are present in the co-authorship network: the observed network is not dense and the level of co-operation between the scientists in the field of nanotechnology seems to be low (Erman and Todorovski, 2011). Diameter refers to the size of the largest geodesic distance between any pair of nodes in the co-authorship network. Number of nodes in the largest component (generally called as giant component) is 4,100 constitutes 58 per cent of total number of nodes. The average degree refers to the number of edges incident was calculated to 9.6.

As the co-authorship network contains 6,965 nodes, a sub graph (k-core) is extracted and visualized in Figure 3. K-core is the largest sub graph of a certain co-author network where nodes have at least k interconnections (Elango *et al.*, 2013). In the visualization, each node represents one author, and the size of the node denotes the number of papers. The interconnecting lines denote the co-authored publications with two authors and thickness denotes the number of co-authored papers. In this sub graph (Figure 3), nodes having 30 or more inter links with other nodes are visualized. Some of the trio (frequently collaborating 3 authors) can be

Figure 4. *Citation network of* Nature Nanotechnology *publications*

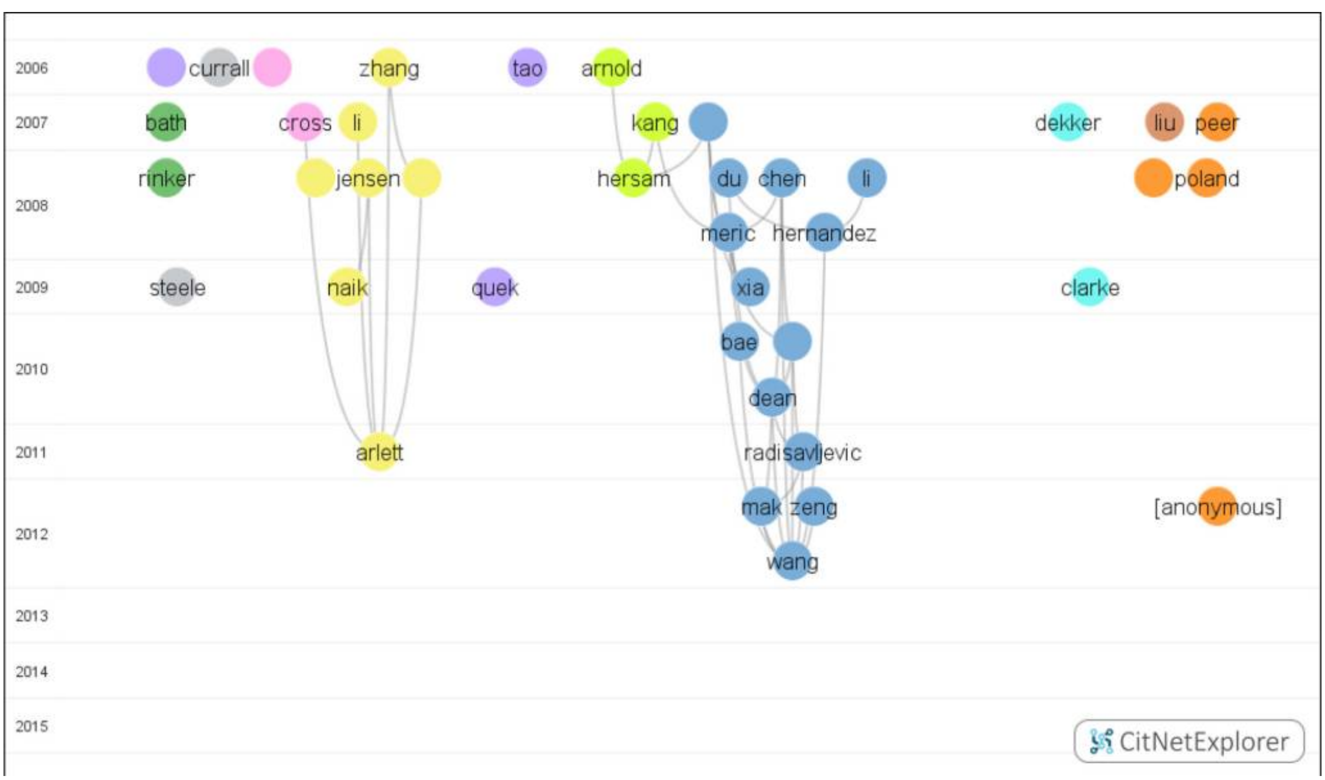


Table V.
Classic articles

TC	Year	Author (s)	Title	Document type	Country of authors	Citation index (R)
4,366	2008	Li *et al.*	Processable aqueous dispersions of graphene nanosheets	Article	Australia, USA	624 (3)
3,168	2009	Park and Ruoff	Chemical methods for the production of graphenes	Review	USA	528 (5)
3,088	2010	Bae *et al.*	Roll-to-roll production of 30-inch graphene films for transparent electrodes	Article	South Korea, Singapore, Japan	618 (4)
2,922	2011	Radisavljevic *et al.*	Single-layer MoS_2 transistors	Article	Switzerland	731 (1)
2,822	2007	Peer *et al.*	Nanocarriers as an emerging platform for cancer therapy	Review	USA, Israel	353 (8)
2,687	2008	Chan *et al.*	High-performance lithium battery anodes using silicon nanowires	Article	USA	384 (6)
2,148	2008	Hernandez *et al.*	High-yield production of graphene by liquid-phase exfoliation of graphite	Article	Ireland, England	307 (10)
2,092	2012	Wang *et al.*	Electronics and optoelectronics of two-dimensional transition metal dichalcogenides	Review	USA, Australia, Switzerland, Ireland	697 (2)
2,084	2008	Eda *et al.*	Large-area ultrathin films of reduced graphene oxide as a transparent and flexible electronic material	Article	USA	298 (11)
1,808	2010	Schwierz	Graphene transistors	Review	Germany	362 (7)
1,667	2010	Dean *et al.*	Boron nitride substrates for high-quality graphene electronics	Article	USA, South Korea, Japan	333 (9)
1,494	2008	Ramanathan *et al.*	Functionalized graphene sheets for polymer nanocomposites	Article	USA	213 (12)
1,387	2007	Avouris *et al.*	Carbon-based electronics	Review	USA	173 (17)
1,376	2008	Das *et al.*	Monitoring dopants by Raman scattering in an electrochemically top-gated graphene transistor	Article	England, India	197 (13)
1,338	2006	Arnold *et al.*	Sorting carbon nanotubes by electronic structure using density differentiation	Article	USA	149 (21)
1,328	2008	Du *et al.*	Approaching ballistic transport in suspended graphene	Article	USA	190 (14)
1,249	2008	Chen *et al.*	Intrinsic and extrinsic performance limits of graphene devices on SiO_2	Article	USA	178 (15)
1,226	2008	Poland *et al.*	Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study	Article	Scotland, England	175 (16)
1,204	2008	Yang *et al.*	Memristive switching mechanism for metal/oxide/metal nanodevices	Article	USA	172 (18)
1,125	2008	Li *et al.*	Highly conducting graphene sheets and Langmuir-Blodgett films	Article	USA, China	161 (19)
1,107	2008	Jiang *et al.*	Nanoparticle-mediated cellular response is size-dependent	Article	Canada	158 (20)

Notes: TC = total citations from time of publication to the date of access; Citation Index = number of citations divided by number of years since publication up to 2015 visualized, for example, Lopez, Cape and Sood. Even though, some authors are having higher number of publications, they had lower number of collaborations with others (e.g. Liu J and Jiang S).

Citation network

CitNetExplorer *(www.citnetexplorer.nl)* was used to explore the citation networks among the publications of *Nature Nanotechnology*. The text file was imported into the tool and visualizes the citation network (Figure 4). The location of the publications in horizontal position is determined by the closeness of the publications in terms of citation relations: generally, a citing publication is located below the corresponding cited publication (Elango *et al.*, 2016). Of the total publications, 40 most frequently cited publications are displayed in Figure 4. Closely related publications are grouped using clustering technique with a resolution parameter of 1.0, where by publications are grouped into 21 clusters and 701 publications do not belong to a cluster. Of 21 clusters, publications to 9 clusters are visualized in the citation network. Publications under grey color are not included in any of the clusters in the visualization. Of the nine clusters in the visualization, most of the frequently cited publications belong to the yellow and blue clusters. Light green color publications dealt with nanotubes (Arnold *et al.*, 2006). Publications under blue color dealt with graphene (Hernandez *et al.*, 2008; Schwierz, 2010). Publications under yellow color dealt with nanomechnical (Jensen *et al.*, 2008; Naik *et al.*, 2009). There are some isolated publications under different clusters in the visualization (Dekker, 2007; Clarke *et al.,* 2009; Poland *et al.*, 2008; Bath and Turberfield, 2007; Tao, 2006).

Classic articles

Of 2,060 publications, 21 publications (1 per cent) received more than 1,000 citations since publication up to date of database access. These publications are identified as classic articles (Garfield, 1976; Ho, 2014). Among the 21 classic articles, 12 studies were related with graphene. More than 50 per cent of classic articles were published in 2008. Out of 21 classic articles, five were published as reviews (approximately, 25 per cent of 21). It is higher than (8 times) over all share of reviews in total publications. Two thirds of the classic articles were published by at least one author from USA. Only one classic article contributed by single author, the remaining had co-authors. Of these 21 classic articles, 9 (42 per cent) articles demonstrated international collaboration which shows that collaboration does not matter in receiving citations. Top cited publication in terms of number of citations by Li *et al.* (2008) reported that chemically converted graphene sheets obtained from graphite can readily form stable aqueous colloids through electrostatic stabilization and make it possible to fabricate homogenous graphene materials using low cost solution processing techniques. Based on this material, there was a lot of research output has been published (Luo *et al.*, 2011). Top ranked publication in terms of citation index by Radisavljevic *et al.* (2011) discusses the preparation of alternate material to grapheme and reported that MOS2 could be complemented to graphene in applications that require thin transparent semiconductors such as optoelectronic and energy harvesting (Table V).

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