Bibliometric Analysis

for the U.S. Environmental Protection Agency/Office of Research and Development's Science and Technology for Sustainability (STS) Research Program

This is a bibliometric analysis of the papers prepared by intramural and extramural researchers of the U.S. Environmental Protection Agency (EPA) of the Science and Technology for Sustainability (STS) Research Program. For this analysis, 662 papers were reviewed, and they were published from 1996 to 2006. These publications were cited 12,887 times in the journals covered by Thomson's *Web of Science*[1] and Scopus[2]. Of these 662 publications, 546 (82%) have been cited at least once in a journal.

Searches of Thomson Scientific's *Web of Science* and Scopus were conducted to obtain times cited data for the STS journal publications. The analysis was completed using Thomson's *Essential Science Indicators (ESI)* and *Journal Citation Reports (JCR)* as benchmarks. *ESI* provides access to a unique and comprehensive compilation of essential science performance statistics and science trends data derived from Thomson's databases. For this analysis, the *ESI* highly cited papers thresholds as well as the hot papers thresholds were used to assess the influence and impact of the STS papers. *JCR* is a recognized authority for evaluating journals. It presents quantifiable statistical data that provide a systematic, objective way to evaluate the world's leading journals and their impact and influence in the global research community. The two key measures used in this analysis to assess the journals in which the EPA STS papers are published are the Impact Factor and Immediacy Index. The Impact Factor is a measure of the frequency with which the "average article" in a journal has been cited in a particular year. The Impact Factor helps evaluate a journal's relative importance, especially when compared to other journals in the same field. The Immediacy Index is a measure of how quickly the "average article" in a journal is cited. This index indicates how often articles published in a journal are cited within the same year and it is useful in comparing how quickly journals are cited.

The report includes a summary of the results of the analysis, an analysis of the 662 STS research papers analyzed by *ESI* field (e.g., chemistry, environment/ecology, engineering), an analysis of the journals in which the STS papers were published, a table of the highly cited researchers in the STS Research Program, and a list of the patents and patent applications resulting from the program.

1 Thomson Scientific's *Web of Science* provides access to current and retrospective multidisciplinary information from approximately 8,830 of the most prestigious, high impact research journals in the world. *Web of Science* also provides cited reference searching.

2 Scopus is a large abstract and citation database of research literature and quality Web sources designed to support the literature research process. Scopus offers access to 15,000 titles from 4,000 different publishers, more than 12,850 academic journals (including coverage of 535 Open Access journals, 750 conference proceedings, and 600 trade publications), 27 million abstracts, 245 million references, 200 million scientific Web pages, and 13 million patent records.

Summary of Results

1. **More than one-quarter of the STS publications are highly cited papers.** A review of the citations indicates that 187 (28.2%) of the STS papers qualify as highly cited when using the *ESI* criteria for the top 10% of highly cited publications. This is 2.8 times the number expected. Thirty-two (4.8%) of the STS papers qualify as highly cited when using the *ESI* criteria for the top 1%, which is 4.8 times the number expected. Six (0.91%) of these papers qualify as very highly cited when using the criteria for the top 0.1%, which is 9.1 times the number anticipated. One paper (0.15%) actually meets the 0.01% threshold for the most highly cited papers, which is 15 times the 0.066 number expected.

2. **The STS papers are more highly cited than the average paper.** Using the *ESI* average citation rates for papers published by field as the benchmark, in 11 of the 17 fields in which the EPA STS papers were published, the ratio of actual to expected cites is greater than 1, indicating that the STS papers are more highly cited than the average papers in those fields. For all 17 fields combined, the ratio of total number of cites to the total number of expected cites (12,887 to 5,134) is 2.5, indicating that the STS papers are more highly cited than the average paper.

3. **One-third of the STS papers are published in high impact journals.** Two hundred twenty-seven (227) of the 662 papers were published in the top 10% of journals ranked by *JCR* Impact Factor, representing 34.3% of EPA's STS papers. This number is 3.4 times higher than expected. Two hundred thirty-nine (239) of the 661 papers appear in the top 10% of journals ranked by *JCR* Immediacy Index, representing 36.1% of EPA's STS papers. This number is 3.6 times higher than expected.

4. **Eight of the STS papers qualify as hot papers.** Using the hot paper thresholds established by *ESI* as a benchmark, 8 hot papers, representing 1.2% of the STS papers, were identified in the analysis. Hot papers are papers that were highly cited shortly after they were published. The number of STS hot papers is 12 times higher than the 0.66 hot papers expected.

5. **The authors of the STS papers cite themselves much less than the average author.** Four hundred seventy-seven (477) of the 12,887 cites are author self-cites. This 3.7% author self-citation rate is well below the accepted range of 10-30% author self-citation rate.

6. **Eight of the authors of the STS papers are included in *ISIHighlyCited.com***, which is a database of the world's most influential researchers who have made key contributions to science and technology during the period from 1981 to 1999.

7. **There were 25 patents issued and 9 patent applications filed** by investigators from 1996 to 2006 for research that was conducted under EPA's STS research program. Seventeen (68%) of the 25 patents have been referenced by 114 other patents.

Highly Cited STS Publications

All of the journals covered by ESI are assigned a field, and to compensate for varying citation rates across scientific fields, different thresholds are applied to each field. Thresholds are set to select highly cited papers to be listed in *ESI*. Different thresholds are set for both field and year of publication. Setting different thresholds for each year allows comparable representation for older and younger papers for each field.

The 662 STS research papers reviewed for this analysis were published in journals that were assigned to 17 of the 22 *ESI* fields. The distribution of the papers among these 17 fields and the number of citations by field are presented in Table 1.

Table 1. STS Papers by *ESI* Fields

No. of Citations	*ESI* Field	No. of EPA STS Papers	Average Cites/Paper
10,179	Chemistry	384	26.51
1,122	Engineering	94	11.94
352	Environment/Ecology	64	5.50
318	Multidisciplinary	2	159.00
294	Biology & Biochemistry	29	10.14
243	Materials Science	41	5.93
94	Computer Science	9	10.44
85	Physics	9	9.44
55	Microbiology	8	6.88
45	Economics & Business	4	11.25
40	Molecular Biology & Genetics	2	20.00
26	Social Sciences, General	7	3.71
17	Plant & Animal Science	2	8.50
16	Agricultural Sciences	2	8.00
1	Pharmacology & Toxicology	2	0.50
0	Clinical Medicine	1	0.00
0	Geosciences	2	0.00
Total = 12,887		**Total = 662**	**19.47**

There are 187 (28.2% of the papers analyzed) highly cited EPA STS papers in 9 of the 17 fields—Chemistry, Engineering, Multidisciplinary, Environment/Ecology, Materials Science, Computer Science, Biology & Biochemistry, Economics & Business, and Plant & Animal Science—when using the *ESI* criteria for the **top 10% of papers**. Table 2 shows the number of EPA papers in those 9 fields that meet the **top 10% threshold in *ESI***.

Table 2. Number of Highly Cited STS Papers by Field (top 10%)

Citations	*ESI* Field	No. of Papers	Average Cites/Paper	% of EPA Papers in Field
7,724	Chemistry	131	58.96	34.11%
974	Engineering	31	3.03	32.98%
315	Multidisciplinary	1	315.00	50.00%
173	Environment/Ecology	6	28.83	9.38%
132	Materials Science	7	18.86	17.07%
81	Computer Science	6	13.50	66.67%
70	Biology & Biochemistry	2	35.00	6.90%
40	Economics & Business	2	20.00	50.00%
17	Plant & Animal Science	1	17.00	50.00%
Total = 9,526		**Total = 187**	**50.94**	**28.25%**

Thirty-two (4.8%) of the papers analyzed qualify as highly cited when using the *ESI* criteria for the **top 1% of papers**. These papers cover six fields—Chemistry, Engineering, Multidisciplinary, Environment/Ecology, Materials Science, and Plant & Animal Science. Table 3 shows the 32 papers by field that meet the **top 1% threshold in *ESI***. The citations for these 32 papers are provided in Tables 4 through 9. There were 6 (0.91%) very highly cited STS papers in the fields of Chemistry, Engineering, and Multidisciplinary. These papers, which meet the **top 0.1% threshold in *ESI*,** are listed in Table 10. One of the STS papers actually meets the **top 0.01% threshold in *ESI*,** which represents 0.15% of the papers. The citation for this paper is provided in Table 11.

Table 3. Number of Highly Cited STS Papers by Field (top 1%)

Citations	*ESI* Field	No. of Papers	Average Cites/Paper	% of EPA Papers in Field
3,482	Chemistry	20	174.10	5.21%
457	Engineering	7	65.28	7.45%

Citations	*ESI* Field	No. of Papers	Average Cites/Paper	% of EPA Papers in Field
315	Multidisciplinary	1	315.00	50.00%
75	Environment/Ecology	2	37.50	3.13%
62	Materials Science	1	62.00	2.44%
17	Plant & Animal Science	1	17.00	50.00%
Total = 4,408		**Total = 32**	**137.75**	**4.83%**

Table 4. Highly Cited STS Papers in the Field of Chemistry (top 1%)

No. of Cites	First Author	Paper
128	Canelas DA	Dispersion polymerization of styrene in supercritical carbon dioxide: importance of effective surfactants. *Macromolecules* 1996;29(8):2818-2821.
365	Li CJ	Aqueous Barbier-Grignard type reaction: scope, mechanism, and synthetic applications. *Tetrahedron* 1996;52(16):5643-5668.
107	Mesiano AJ	Supercritical biocatalysis. *Chemical Reviews* 1999;99(2):623-633.
193	Matyjaszewski K	Transition metal catalysis in controlled radical polymerization: atom transfer radical polymerization. *Chemistry-A European Journal* 1999;5(11):3095-3102.
247	Patten TE	Copper(I)-catalyzed atom transfer radical polymerization. *Accounts of Chemical Research* 1999;32(10):895-903.
380	Li CJ	Organic syntheses using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
573	Varma RS	Solvent-free organic syntheses - using supported reagents and microwave irradiation. *Green Chemistry* 1999;1(1):43-55.
105	Matyjaszewski K	Gradient copolymers by atom transfer radical copolymerization. *Journal of Physical Organic Chemistry* 2000;13(12):775-786.
113	Varma RS	Solvent-free accelerated organic syntheses using microwaves. *Pure and Applied Chemistry* 2001;73(1):193-198.
156	Blanchard LA	High-pressure phase behavior of ionic liquid/CO_2 systems. *Journal of Physical Chemistry B* 2001;105(12):2437-2444.
450	Huddleston JG	Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imidazolium cation. *Green Chemistry* 2001;3(4):156-164.

No. of Cites	First Author	Paper
70	Holbrey JD	Efficient, halide free synthesis of new, low cost ionic liquids: 1,3-dialkylimidazolium salts containing methyl- and ethyl-sulfate anions. *Green Chemistry* 2002;4(5):407-413.
104	Wei CM	Enantioselective direct-addition of terminal alkynes to imines catalyzed by copper(I)pybox complex in water and in toluene. *Journal of the American Chemical Society* 2002;124(20):5638-5639.
111	Varma RS	Clay and clay-supported reagents in organic synthesis. *Tetrahedron* 2002;58(7):1235-1255.
126	Swatloski RP	Dissolution of cellose with ionic liquids. *Journal of the American Chemical Society* 2002;124(18):4974-4975.
56	Holbrey JD	Crystal polymorphism in 1-butyl-3-methylimidazolium halides: supporting ionic liquid formation by inhibition of crystallization. *Chemical Communications* 2003;14:1636-1637.
73	Kaar JL	Impact of ionic liquid physical properties on lipase activity and stability. *Journal of the American Chemical Society* 2003;125(14):4125-4131.
103	Swatloski RP	Ionic liquids are not always green: hydrolysis of 1-butyl-3-methylimidazolium hexafluorophosphate. *Green Chemistry* 2003;5(4):361-363.
17	Lutz JF	Nuclear magnetic resonance monitoring of chain-end functionality in the atom transfer radical polymerization of styrene. *Journal of Polymer Science Part A-Polymer Chemistry* 2005;43(4):897-910.
5	Ju Y	Aqueous N-heterocyclization of primary amines and hydrazines with dihalides: microwave-assisted syntheses of N-azacycloalkanes, isoindole, pyrazole, pyrazolidine, and phthalazine derivatives. *Journal of Organic Chemistry* 2006;71(1):135-141.

Table 5. Highly Cited STS Papers in the Field of Engineering (top 1%)

No. of Cites	First Author	Paper
56	Chandler K	Alkylation reactions in near-critical water in the absence of acid catalysts. *Industrial & Engineering Chemistry Research* 1997;36(12):5175-5179.
53	Clancy JL	UV light inactivation of Cryptosporidium oocysts. *Journal of the American Water Works Association* 1998;90(9):92-102.
62	Bukhari Z	Medium-pressure UV for oocyst inactivation. *Journal of the American Water Works Association* 1999;91(3):86-94.

No. of Cites	First Author	Paper
179	Blanchard LA	Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.
37	Abraham MH	Some novel liquid partitioning systems: water-ionic liquids and aqueous biphasic systems. *Industrial & Engineering Chemistry Research* 2003;42(3):413-418.
54	Ceraolo M	Modelling static and dynamic behaviour of proton exchange membrane fuel cells on the basis of electro-chemical description. *Journal of Power Sources* 2003;113(1):131-144.
16	Choi Y	Kinetics, simulation and insights for CO selective oxidation in fuel cell applications. *Journal of Power Sources* 2004;129(2):246-254.

Table 6. Highly Cited STS Paper in the Field of Multidisciplinary (top 1%)

No. of Cites	First Author	Paper
315	Blanchard LA	Green processing using ionic liquids and CO_2. *Nature* 1999;399(6731):28-29.

Table 7. Highly Cited STS Papers in the Field of Environment/Ecology (top 1%)

No. of Cites	First Author	Paper
42	Bare JC	TRACI: the tool for the reduction and assessment of chemical and other environmental impacts. *Journal of Industrial Ecology* 2003;6(3-4):49-78.
33	Suh S	System boundary selection in life-cycle inventories using hybrid approaches. *Environmental Science & Technology* 2004;38(3):657-664.

Table 8. Highly Cited STS Paper in the Field of Materials Science (top 1%)

No. of Cites	First Author	Paper
62	Davis KA	Statistical, gradient, block, and graft copolymers by controlled/living radical polymerizations. *Materials Today* 2002;159:1-169.

Table 9. Highly Cited STS Paper in the Field of Plant & Animal Science (top 1%)

No. of Cites	First Author	Paper
17	Walsh CJ	The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society* 2005;24(3):706-723.

Table 10. Very Highly Cited STS Papers (top 0.1%)

ESI Field	No. of Cites	First Author	Paper
Chemistry	380	Li CJ	Organic syntheses using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
	573	Varma RS	Solvent-free organic syntheses - using supported reagents and microwave irradiation. *Green Chemistry* 1999;1(1):43-55.
	450	Huddleston JG	Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imidazolium cation. *Green Chemistry* 2001;3(4):156-164.
Engineering	179	Blanchard LA	Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.
	54	Ceraolo M	Modelling static and dynamic behaviour of proton exchange membrane fuel cells on the basis of electro-chemical description. *Journal of Power Sources* 2003;113(1):131-144.
Multidisciplinary	315	Blanchard LA	Green processing using ionic liquids and CO_2. *Nature* 1999;399(6731):28-29.

Table 11. Very Highly Cited STS Paper (top 0.01%)

ESI Field	No. of Cites	First Author	Paper
Multidisciplinary	315	Blanchard LA	Green processing using ionic liquids and CO_2. *Nature* 1999;399(6731):28-29.

Ratio of Actual Cites to Expected Citation Rates

The expected citation rate is the average number of cites that a paper published in the same journal in the same year and of the same document type (article, review, editorial, etc.) has received from the year of publication to the present. Using the *ESI* average citation rates for papers published by field as the benchmark, in 11 of the 17 fields in which the EPA STS papers were published, the ratio of actual to expected cites is greater than 1, indicating that the STS papers are more highly cited than the average papers in those fields (see Table 12). For all 17 fields combined, the ratio of total number of cites to the total number of expected cites (12,887 to 5,134) is 2.51, indicating that the STS papers are more highly cited than the average paper.

Table 12. Ratio of Actual Cites to Expected Cites for STS Papers by Field

***ESI* Field**	**Total Cites**	**Expected Cite Rate**	**Ratio**
Agricultural Sciences	16	10.40	1.54
Biology & Biochemistry	294	368.91	0.80
Chemistry	10,179	3,574.33	2.85
Clinical Medicine	0	14.37	0.00
Computer Science	94	27.08	3.47
Economics & Business	45	24.82	1.81
Engineering	1,122	326.19	3.44
Environment/Ecology	352	368.01	0.96
Geosciences	0	15.58	0.00
Materials Science	243	172.98	1.40
Microbiology	55	52.59	1.04
Molecular Biology & Genetics	40	45.50	0.88
Multidisciplinary	318	6.68	47.60
Pharmacology & Toxicology	1	27.79	0.04
Physics	85	72.61	1.17
Plant & Animal Science	17	1.34	12.69
Social Sciences, General	26	24.46	1.06
TOTAL	**12,887**	**5,133.64**	**2.51**

***JCR* Benchmarks**

Impact Factor. The *JCR* Impact Factor is a well known metric in citation analysis. It is a measure of the frequency with which the "average article" in a journal has been cited in a particular year. The Impact Factor helps evaluate a journal's relative importance, especially when compared to others in the same field. The Impact Factor is calculated by dividing the number of citations in the current year to articles published in the 2 previous years by the total number of articles published in the 2 previous years.

Table 13 indicates the number of STS papers published in the top 10% of journals, based on the *JCR* Impact Factor. Two hundred twenty-seven (227) of 662 papers were published in the top 10% of journals, representing 34.3% of EPA's STS papers. This indicates that more than one-third of the STS papers are published in the highest quality journals as determined by the *JCR* Impact Factor, which is 3.4 times higher than the expected percentage.

Table 13. STS Papers in Top 10% of Journals by *JCR* Impact Factor

EPA STS Papers in that Journal	Journal	Impact Factor (IF)	*JCR* IF Rank
1	Science	30.927	6
1	Nature	29.273	11
1	Chemical Reviews	20.869	23
2	Accounts of Chemical Research	13.141	62
1	Aldrichimica Acta	9.917	97
2	Angewandte Chemie-International Edition	9.596	108
18	Journal of the American Chemical Society	7.419	170
2	Advanced Functional Materials	6.770	190
1	Analytical Chemistry	5.635	242
1	Journal of Medicinal Chemistry	4.926	313
2	Chemistry-A European Journal	4.907	314
4	Chemistry of Materials	4.818	327
4	Journal of Catalysis	4.780	332
1	Frontiers in Ecology and the Environment	4.745	334
1	Bioscience	4.708	336
1	Advanced Synthesis & Catalysis	4.632	347
1	Ecology	4.506	366
1	International Review of Cytology	4.481	372
1	Biotechnology Advances	4.455	381
23	Chemical Communications	4.426	385
11	Organic Letters	4.368	397
3	Journal of Bacteriology	4.167	440
1	Applied Physics Letters	4.127	450
22	Environmental Science & Technology	4.054	467

EPA STS Papers in that Journal	Journal	Impact Factor (IF)	*JCR* IF Rank
5	Journal of Physical Chemistry B	4.033	474
22	Macromolecules	4.024	479
1	Inorganic Chemistry	3.851	535
1	Applied and Environmental Microbiology	3.818	544
3	Applied Catalysis B-Environmental	3.809	547
5	Langmuir	3.705	569
5	Journal of Materials Chemistry	3.688	575
24	Journal of Organic Chemistry	3.675	577
2	Biomacromolecules	3.618	598
1	Journal of Mass Spectrometry	3.574	618
1	Crystal Growth & Design	3.551	627
3	Organometallics	3.473	651
1	Microporous and Mesoporous Materials	3.355	689
1	Chemical Research in Toxicology	3.339	699
28	Green Chemistry	3.255	722
3	Current Organic Chemistry	3.102	775
12	Journal of Polymer Science Part A-Polymer Chemistry	3.027	806
3	Water Research	3.019	809
Total = 227			

Immediacy Index. The *JCR* Immediacy Index is a measure of how quickly the *average article* in a journal is cited. It indicates how often articles published in a journal are cited within the year they are published. The Immediacy Index is calculated by dividing the number of citations to articles published in a given year by the number of articles published in that year.

Table 14 indicates the number of STS papers published in the top 10% of journals, based on the *JCR* Immediacy Index. Two hundred thirty-nine (239) of the 662 papers appear in the top 10% of journals, representing 36.1% of the STS papers. This indicates that one-third of the STS papers are published in the highest quality journals as determined by the *JCR* Immediacy Index, which is 3.6 times higher than the expected percentage.

Table 14. STS Papers in Top 10% of Journals by *JCR* Immediacy Index

EPA STS Papers in that Journal	Journal	Immediacy Index (II)	*JCR* II Rank
1	Science	6.398	6
1	Nature	5.825	11
1	Chemical Reviews	4.523	23
2	Accounts of Chemical Research	3.414	36
2	Angewandte Chemie-International Edition	2.109	82
18	Journal of the American Chemical Society	1.435	162
2	Chemistry-A European Journal	1.111	266
23	Chemical Communications	1.029	296
11	Organic Letters	0.993	325
1	Crystal Growth & Design	0.989	328
1	Journal of Medicinal Chemistry	0.937	360
1	International Review of Cytology	0.919	369
2	Advanced Functional Materials	0.890	400
3	Journal of Bacteriology	0.874	413
24	Journal of Organic Chemistry	0.862	418
1	Journal of the North American Benthological Society	0.797	479
3	Journal of the Chemical Society-Perkin Transactions 1	0.793	481
22	Macromolecules	0.767	497
3	Organometallics	0.762	501
4	Journal of Catalysis	0.761	504
1	Bioscience	0.731	538
1	Chemical Research in Toxicology	0.729	542
5	Journal of Materials Chemistry	0.728	545
1	Advanced Synthesis & Catalysis	0.726	551
1	Aldrichimica Acta	0.714	564
4	Chemistry of Materials	0.714	564
1	Analytical Chemistry	0.713	569
1	Inorganic Chemistry	0.713	569

EPA STS Papers in that Journal	Journal	Immediacy Index (II)	*JCR* II Rank
5	Journal of Physical Chemistry B	0.705	578
3	Current Organic Chemistry	0.674	618
2	Metabolic Engineering	0.674	618
1	Journal of Mass Spectrometry	0.660	645
8	International Journal of Life Cycle Assessment	0.644	669
2	New Journal of Chemistry	0.634	688
2	Biomacromolecules	0.633	690
28	Green Chemistry	0.631	695
1	Ecology	0.621	710
5	Langmuir	0.610	724
5	Synlett	0.578	787
1	Bioorganic & Medicinal Chemistry Letters	0.573	799
12	Journal of Polymer Science Part A-Polymer Chemistry	0.564	819
1	Applied Physics Letters	0.551	848
22	Environmental Science & Technology	0.541	874
Total = 239			

Hot Papers

ESI establishes citation thresholds for hot papers, which are selected from the highly cited papers in different fields, but the time frame for citing and cited papers is much shorter—papers must be cited within 2 years of publication and the citations must occur in a 2-month time period. Papers are assigned to 2-month periods and thresholds are set for each period and field to select 0.1% of papers. There were no hot papers identified for the current 2-month period (i.e., September-October 2006), but there were a number of hot papers identified from previous periods.

Using the hot paper thresholds established by *ESI* as a benchmark, 8 hot papers, representing 1.2% of the STS papers, were identified in three fields—Chemistry, Engineering, and Plant & Animal Science. The number of STS hot papers is 12 times higher than expected. The hot papers are listed in Table 15.

Table 15. Hot Papers Identified Using *ESI* Thresholds

Field	*ESI* Hot Papers Threshold	No. of Cites in 2-Month Period	Paper
Chemistry	10	10 cites in March-April 2001	Matyjaszewski K. Transition metal catalysis in controlled radical polymerization: atom transfer radical polymerization. *Chemistry-A European Journal* 1999;5(11):3095-3102.
	10	10 cites in January-February 2001	Li C-J, Chan T-H. Organic synthesis using indium-mediated and catalyzed reactions in aqueous media. *Tetrahedron* 1999;55(37):11149-11176.
	9	9 cites in October-November 2000	Patten TE, Matyjaszewski K. Copper(I)-catalyzed atom transfer radical polymerization. *Accounts of Chemical Research* 1999;32(10):895-903.
	9	9 cites in April-May 2003	Huddleston JG, Visser AE, Reichert WM, et al. Characterization and comparison of hydrophilic and hydrophobic room temperature ionic liquids incorporating the imadazolium cation. *Green Chemistry* 2001;3(4):156-164.
Engineering	4	5 cites in August 2000	Clancy JL, Hargy TM, Marshall MM, et al. UV light inactivation of Cryptosporidium oocysts. *Journal of the American Water Works Association* 1998;90(9):92-102.
	4	6 cites in September-October 2002	Blanchard LA, Brennecke JF. Recovery of organic products from ionic liquids using supercritical carbon dioxide. *Industrial & Engineering Chemistry Research* 2001;40(1):287-292.
	5	5 cites in April-May 2004	Abraham MH, Zissimos AM, Huddleston JG, et al. Some novel liquid partitioning systems: water-ionic liquids and aqueous biphasic systems. *Industrial & Engineering Chemistry Research* 2003;42(3):4131-418.
Plant & Animal Science	5	7 cites in September 2005	Walsh CJ, Roy AH, Feminella JW, et al. The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society* 2005;24(3):706-723.

Author Self-Citation

Self-citations are journal article references to articles from that same author (i.e., the first author). Because higher author self-citation rates can inflate the number of citations, the author self-citation rate was calculated for the STS papers. Of the 12,887 total cites, 477 are author self-cites—a 3.7% author self-citation rate. Garfield and Sher[3] found that authors working in research-based disciplines tend to cite themselves on the average of 20% of the time. MacRoberts and MacRoberts[4] claim that approximately 10% to 30% of all the citations listed fall into the category of author self-citation. Kovacic and Misak[5] recently reported a 20% author self-citation rate for medical literature. Therefore, the 3.7% self-cite rate for the STS papers is well below the range for author self-citation.

Highly Cited Researchers

A search of Thomson's *ISIHighlyCited.com* revealed that 8 (0.9%) of the 931 authors of the STS papers are highly cited researchers. *ISIHighlyCited.com* is a database of the world's most influential researchers who have made key contributions to science and technology during the period from 1981 to 1999. The highly cited researchers identified during this analysis of the STS publications are presented in Table 16.

Table 16. Highly Cited Researchers Authoring STS Publications

Highly Cited Researcher	Affiliation	*ESI* Field
Abraham, Michael H.	University College London	Chemistry
Calabrese, Joe C.	E.I. Dupont de Nemours Co.	Chemistry
Groffman, Peter Mark	Institute of Ecosystem Studies	Environment/Ecology
Haddon, Robert C.	University of California–Riverside	Physics
Katritzky, Alan R.	University of Florida	Chemistry
Matyjaszewski, Krzysztof	Carnegie Mellon University	Chemistry
Paquette, Leo Armand	Ohio State University	Chemistry
Suidan, Makram T.	University of Cincinnati	Environment/Ecology
Total = 8		

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Patents

There were 25 patents issued to and 9 patent applications filed by investigators from 1996 to 2006 for research that was conducted under EPA's STS research program. Seventeen (68%) of the 25 patents have been referenced by 114 other patents. These patents and patent applications, along with the patents that reference them, are listed in Table 17.

Table 17. Patents and Patent Applications from the STS Research Program (1996-2006)

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
5,647,221	Garris Jr. CA	Pressure exchanging ejector and refrigeration apparatus and method	7/15/97	Referenced by 14 patents: (1) 7,143,602 Ejector-type depressurizer for vapor compression refrigeration system (2) 7,121,906 Method and apparatus for decreasing marine vessel power plant exhaust temperature (3) 7,059,147 Cooling system for a vehicle (4) 7,043,912 Apparatus for extracting exhaust heat from waste heat sources while preventing backflow and corrosion (5) 6,904,760 Compact refrigeration system (6) 6,835,484 Supersonic vapor compression and heat rejection cycle (7) 6,647,742 Expander driven motor for auxiliary machinery (8) 6,550,265 Ejector cycle system (9) 6,434,943 Pressure exchanging compressor-expander and methods of use (10) 6,248,154 Operation process of a pumping-ejection apparatus and related apparatus (11) 6,192,692 Liquid powered ejector (12) 6,164,078 Cryogenic liquid heat exchanger system with fluid ejector (13) 6,138,456 Pressure exchanging ejector and methods of use (14) 6,038,876 Motor vehicle air-conditioning system
5,907,075	Subramanian B, Clark MC	Solid acid supercritical alkylation reactions using carbon dioxide and/or other co-solvents	5/25/99	Referenced by 7 patents: (1) 7,090,830 Drug condensation aerosols and kits (2) 6,924,407 Pressure-tuned solid catalyzed heterogeneous chemical reactions (3) 6,914,105 Continuous process for making polymers in carbon dioxide (4) 6,887,813 Method for reactivating solid catalysts used in alkylation reactions

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
				(5) 6,806,332 Continuous method and apparatus for separating polymer from a high pressure carbon dioxide fluid stream (6) 6,579,821 Method for reactivating solid catalysts used in alkylation reactions (7) 6,103,948 Solid catalyzed isoparaffin alkylation at supercritical fluid and near-supercritical fluid conditions
6,013,774	Meister JJ, Chen MJ	Biodegradable plastics and composites from wood	1/11/00	Referenced by 1 patent: (1) 6,488,997 Degradable composite material, its disposable products and processing method thereof
6,039,878	Sikdar S, Vane L	Recovery of volatile organic compounds in water by pervaporation	3/21/00	Referenced by 3 patents: (1) 6,858,145 Method of removing organic impurities from water (2) 6,335,202 Method and apparatus for on-line measurement of the permeation characteristics of a permeant through dense nonporous membrane (3) 6,264,726 Method of filtering a target compound from a first solvent that is above its critical density
6,103,121	Bhattacharyya D, Bachas LG, Cullen L, Hestekin JA, Sikdar S	Membrane-based sorbent for heavy metal sequestration	8/15/00	Referenced by 3 patents: (1) 6,544,419 Method of preparing a composite polymer and silica-based membrane (2) 6,544,418 Preparing and regenerating a composite polymer and silica-based membrane (3) 6,533,938 Polymer enhanced diafiltration: filtration using PGA
6,117,328	Sikdar SK, Ji W, Wang S-t	Adorbent-filled membranes for pervaporation	9/12/00	Referenced by 5 patents: (1) 7,014,681 Flexible and porous membranes and adsorbents, and method for the production thereof (2) 6,779,529 Cigarette filter (3) 6,740,143 Mixed matrix nanoporous carbon membranes (4) 6,706,531 Device for conditioning a polluted soil-sample-method of analysis by pyrolysis (5) 6,500,233 Purification of p-xylene using composite mixed matrix membranes
6,138,456	Garris CA	Pressure exchanging ejector and methods of use	10/31/00	Referenced by 8 patents: (1) 7,143,602 Ejector-type depressurizer for vapor compression refrigeration system (2) 7,137,243 Constant volume combustor (3) 6,966,199 Ejector with throttle controllable nozzle and ejector cycle using the same

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
				(4) 6,904,769 Ejector-type depressurizer for vapor compression refrigeration system (5) 6,729,158 Ejector decompression device with throttle controllable nozzle (6) 6,550,265 Ejector cycle system (7) 6,471,489 Supersonic 4-way self-compensating fluid entrainment device (8) 6,434,943 Pressure exchanging compressor-expander and methods of use
6,139,742	Bhattacharyya D, Bachas LG, Cullen L, Hestekin JA, Sikdar SK	Membrane-based sorbent for heavy metal sequestration	10/31/00	Referenced by 5 patents: (1) 7,049,366 Acrylic acid composition and its production process, and process for producing water-absorbent resin using this acrylic acid composition, and water-absorbent resin (2) 7,009,010 Water-absorbent resin and production process therefor (3) 6,544,419 Method of preparing a composite polymer and silica-based membrane (4) 6,544,418 Preparing and regenerating a composite polymer and silica-based membrane (5) 6,306,301 Silica-based membrane sorbent for heavy metal sequestration
6,306,301	Bhattacharyya D, Ritchie SM, Bachas LG, Hestekin JA, Sikdar SK	Silica-based membrane sorbent for heavy metal sequestration	10/23/01	Referenced by 2 patents: (1) 6,544,419 Method of preparing a composite polymer and silica-based membrane (2) 6,544,418 Preparing and regenerating a composite polymer and silica-based membrane
6,434,943	Garris CA	Pressure exchanging compressor-expander and methods of use	8/20/02	Referenced by 6 patents: (1) 7,137,243 Constant volume combustor (2) 7,104,068 Turbine component with enhanced stagnation prevention and corner heat distribution (3) RE39,217 Centrifugal pump having oil misting system with pivoting blades (4) 6,663,991 Fuel cell pressurization system (5) 6,608,418 Permanent magnet turbo-generator having magnetic bearings (6) 6,551,055 Centrifugal pump having oil misting system with pivoting blades
6,512,060	Matyjaszewski K, Gaynor SG, Coco S	Atom or group transfer radical polymerization	1/28/03	Referenced by 11 patents: (1) 7,157,530 Catalyst system for controlled polymerization (2) 7,125,938 Atom or group transfer radical polymerization (3) 7,064,166 Process for monomer sequence

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
				control in polymerizations (4) 7,056,455 Process for the preparation of nanostructured materials (5) 7,049,373 Process for preparation of graft polymers (6) 7,019,082 Polymers, supersoft elastomers and methods for preparing the same (7) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and properties (8) 6,790,919 Catalyst system for controlled polymerization (9) 6,759,491 Simultaneous reverse and normal initiation of ATRP (10) 6,720,395 Method for producing a stellar polymer (11) 6,627,314 Preparation of nanocomposite structures by controlled polymerization
6,538,091	Matyjaszewski K, Gaynor SG, Coco S	Atom or group transfer radical polymerization	3/25/03	Referenced by 11 patents: (1) 7,157,530 Catalyst system for controlled polymerization (2) 7,125,938 Atom or group transfer radical polymerization (3) 7,064,166 Process for monomer sequence control in polymerizations (4) 7,056,455 Process for the preparation of nanostructured materials (5) 7,049,373 Process for preparation of graft polymers (6) 7,034,065 Ink jet ink composition (7) 7,019,082 Polymers, supersoft elastomers and methods for preparing the same (8) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and properties (9) 6,790,919 Catalyst system for controlled polymerization (10) 6,759,491 Simultaneous reverse and normal initiation of ATRP (11) 6,713,530 Ink jet ink composition
6,541,580	Matyjaszewski K, Gaynor SG, Coco S	Atom or group transfer radical polymerization	4/1/03	Referenced by 8 patents: (1) 7,125,938 Atom or group transfer radical polymerization (2) 7,064,166 Process for monomer sequence

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
				control in polymerizations (3) 7,056,455 Process for the preparation of nanostructured materials (4) 7,049,373 Process for preparation of graft polymers (5) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and properties (6) 6,884,748 Process for producing fluorinated catalysts (7) 6,790,919 Catalyst system for controlled polymerization (8) 6,759,491 Simultaneous reverse and normal initiation of ATRP
6,544,418	Bhattacharyya D, Ritchie SM, Bachas LG, Hestekin JA, Sikdar SK	Preparing and regenerating a composite polymer and silica-based membrane	4/8/03	Referenced by none
6,544,419	Bhattacharyya D, Ritchie SM, Bachas LG, Hestekin JA, Sikdar SK	Method of preparing a composite polymer and silica-based membrane	4/8/03	Referenced by none
6,562,605	Beckman EJ, Ghenciu EJ, Becker NT, Steele LM	Extraction of water soluble biomaterials from fluids using a carbon dioxide/surfactant mixture	5/13/03	Referenced by none
6,624,262	Matyjaszewski K, Tsarevsky N	Polymerization process for ionic monomers	9/23/03	Referenced by 9 patents: (1) 7,157,530 Catalyst system for controlled polymerization (2) 7,125,938 Atom or group transfer radical polymerization (3) 7,064,166 Process for monomer sequence control in polymerizations (4) 7,056,455 Process for the preparation of nanostructured materials (5) 7,049,373 Process for preparation of graft polymers (6) 7,019,082 Polymers, supersoft elastomers and

Patent No. or Applica-tion No.	Inventor(s)	Title	Issue Date or Applica-tion Date	No. of Patents that Referenced This Patent
				methods for preparing the same (7) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and properties (8) 6,790,919 Catalyst system for controlled polymerization (9) 6,759,491 Simultaneous reverse and normal initiation of ATRP
6,624,263	Matyjaszewski K, Wang JS	(Co) polymers and a novel polymerization process based on atom (or group) transfer radical polymerization	9/23/03	Referenced by 9 patents: (1) 7,157,530 Catalyst system for controlled polymerization (2) 7,125,938 Atom or group transfer radical polymerization (3) 7,064,166 Process for monomer sequence control in polymerizations (4) 7,056,455 Process for the preparation of nanostructured materials (5) 7,049,373 Process for preparation of graft polymers (6) 7,019,082 Polymers, supersoft elastomers and methods for preparing the same (7) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and properties (8) 6,790,919 Catalyst system for controlled polymerization (9) 6,759,491 Simultaneous reverse and normal initiation of ATRP
6,627,314	Matyjaszewski K, Pyun J	Preparation of nanocomposite structures by controlled polymerization	9/30/03	Referenced by 11 patents: (1) 7,157,530 Catalyst system for controlled polymerization (2) 7,125,938 Atom or group transfer radical polymerization (3) 7,064,166 Process for monomer sequence control in polymerizations (4) 7,056,455 Process for the preparation of nanostructured materials (5) 7,049,373 Process for preparation of graft polymers (6) 7,019,082 Polymers, supersoft elastomers and methods for preparing the same (7) 6,887,962 Processes based on atom (or group) transfer radical polymerization and novel (co)polymers having useful structures and

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
				properties (8) 6,858,372 Resist composition with enhanced X-ray and electron sensitivity (9) 6,797,380 Nanoparticle having an inorganic core (10) 6,790,919 Catalyst system for controlled polymerization (11) 6,759,491 Simultaneous reverse and normal initiation of ATRP
6,663,991	Garris CA	Fuel cell pressurization system	12/16/03	Referenced by none
6,755,975	Vane LM, Mairal AP, Ng A, Alvarez FR, Baker RW	Separation process using pervaporation and dephlegmation	6/29/04	Referenced by 1 patent: (1) 6,899,743 Separation of organic mixtures using gas separation or pervaporation and dephlegmation
6,759,491	Matyjaszewski K, Gromada J, Li M	Simultaneous reverse and normal initiation of ATRP	7/6/04	Referenced by none
6,777,374	Sahle-Demessie E, Biswas P, Gonzalez MA, Wang Z-M, Sikdar SK	Process for photo-induced selective oxidation of organic chemicals to alcohols, ketones and aldehydes using flame deposited nano-structured photocatalyst	8/17/04	Referenced by none
6,881,364	Vane LM, Ponangi RP	Hydrophilic mixed matrix materials having reversible water absorbing properties	4/19/05	Referenced by none

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
6,900,261	Wool RP, Lu J, Khot SN	Sheet molding compound resins from plant oils	5/31/05	Referenced by none
Application No. 20020110699	Yan Y, Cheng X, Wang Z	Metal surfaces coated with molecular sieve for corrosion resistance	8/15/02	
Application No. 20040044152	Matyjaszewski K, Tsarevsky N	Polymerization processes for ionic monomers	3/4/04	
Application No. 20040122189	Matyjaszewski K, Tsarevsky N	Stabilization of transition metal complexes for catalysis in diverse environments	6/24/04	
Application No. 20040171779	Matyjaszewski K, Gaynor SG, Paik HJ, Pintauer T, Pyun J, Qiu J, Teodorescu M, Xia J, Zhabg X, Miller PJ	Catalytic processes for the controlled polymerization of free radically (Co)polymeriz-able monomers and functional polymeric systems prepared thereby	9/2/04	
Application No. 20060093806	Yan Y, Beving D	High aluminum zeolite coatings on corrodible metal surfaces	5/4/06	
Application No. 20060239831	Garris Jr. CA	Pressure exchange ejector	10/26/06	
Application No.: 20020039673	Garris CA	Fuel cell pressurization system and method of use	4/4/02	

Patent No. or Application No.	Inventor(s)	Title	Issue Date or Application Date	No. of Patents that Referenced This Patent
Application No.: 20050019240	Lu XC, Wu X	Flue gas purification process using a sorbent polymer composite material	1/27/05	
Application No.: 20040110893	Matyjaszewski K, Pakula T	Polymers, supersoft elastomers and methods for preparing the same	6/10/04	

This bibliometric analysis was prepared by
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in Gaithersburg, Maryland
under EPA Contract No. EP-C-05-015