Functional Textiles – Trends and Analysis of Scientific Knowledge

A Bibliometric Assessment

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Boosting collaboration between research centres and industry to enhance rapid industrial uptake of Innovative Functional Textile Structures and Textile related Materials in a Mondial Market
Introduction

Before starting with new scientific work and for establishing networks in the future scanning and assessing a research field with scientometric and bibliometric methods is an important step. In 2BFUNTEX, a collaborative EU project, scientific literature and patents regarding “Functional Textiles and Fibers” were analysed and clustered in order to identify

- core and emerging topics and technologies,
- their dynamics,
- as well as the most important organizations, researchers and the connections between them.

Therefore networks of scientific literature and patents were created. The extracted information serves as basis for further discussions and support for multidisciplinary teams for identification of relevant players in their research field.
Basic Idea and Research Questions

The basic idea is to get an overview of issues of “Functional Textiles” in scientific literature and patent data.

- Which research topics can be detected in “Functional Textiles”?
  - Which of the topics show an increased research activity over the past years and are therefore emerging?
  - In which parts of the world are there activities?
  - Which organizations are the most active/visible ones in those emerging topics?
  - Which other themes are closely connected to the identified topics?
Monitoring of research and technology using BibTechMon™

Methods
Relational Bibliometrics using BibTechMon™, Science Mapping, Network Analysis, Research Portfolios

Data
Databases from Literature or Patents

Results
Strategic Position, Scenarios, Roadmaps, Emerging Technologies

Knowledge Bases

Networks

World map of Publication Activity

Research Fronts

Research portfolios (Emerging topics)
Data - Search Strategy

Search Strategy in Web of Science

- Topic=(**functional** OR **wearable** OR **smart** OR **antibacterial** OR **electronic*** OR (**flame retardant**) OR (**self cleaning**) OR **permeability**) AND Topic=(**textil*** OR **clothes**) NOT Topic=(**snake** OR **snail** OR **endotoxin*** OR **dye***)
- OR Topic=(**fibre** OR **fiber**) AND Topic=(**textil*** OR **cloth***) NOT Topic=(**snake** OR **snail** OR **endotoxin*** OR **dye***)
- OR Topic=((**smart** AND **color***) OR (smart AND **colour***) AND **textil***) NOT Topic=(**COLORECTAL**)  

- First search: 1989 until 23.July 2012; number of recorded articles: **8,931**
- **Update 09.October 2015**; number of recorded articles: **13,738**
Statistic Results 2015
Publication Years
Development of publications from 1990 to 2015
Countries with most Publications - Development from 2012

Top Countries
"Textiles AND Function AND Fibre"
Countries with most Publications – Development from 2012

The bar charts display the percentage of publications for different countries and regions, focusing on the terms "Textiles AND Function AND Fibre". The top 30 countries in terms of publications are highlighted, with the USA, China, and Europe leading the list.

The charts show a clear trend of publication dominance by these regions, indicating a strong focus on textile-related research and development in these areas.
Most Visible Organisations - Development from 2012

Top 30 Institutions
"Textiles AND Function AND Fibre"

Europe
USA
North and South America
China
Asia
Middle East
Africa
Australia, New Zealand
# Changes in Publication Activity of Organisations

1. HONG KONG POLYTECH UNIV  
2. DONGHUA UNIV  
3. TECH UNIV DRESDEN (was 6)  
4. N CAROLINA STATE UNIV  
5. CHINESE ACAD SCI (was 23)  
6. TIANJIN POLYTECH UNIV (was 10)  
7. TECH UNIV LODZ (was 4)  
8. KATHOLIEKE UNIV LEUVEN  
9. ISLAMIC AZAD UNIV (was 32)  
10. UNIV GHENT (was 15)  
11. RHEIN WESTFAL TH AACHEN  
12. UNIV ZAGREB (was 5)  
13. INDIAN INST TECHNOL (was 8)  
14. UNIV MINHO  
15. DEAKIN UNIV (was 20)  
16. UNIV NOTTINGHAM  
17. TECH UNIV LIBEREC (was 49)  
18. GEORGIA INST TECHNOL  
19. EGE UNIV (was 24)  
20. UNIV MANCHESTER  
21. UNIV DELAWARE  
22. SOOCHOW UNIV (was 86)  
23. UNIV LEEDS (was 14)  
24. KAUNAS UNIV TECHNOL (was 34)  
25. USA (was 11)  
26. FENG CHIA UNIV (was 37)  
27. USDA ARS (was 12)  
28. NATL RES CTR (was 47)  
29. NATL UNIV SINGAPORE (was 17)  
30. JIANGNAN UNIV (was 49)  
31. UNIV LJUBLJANA (was 28)  
32. CORNELL UNIV (was 27)  
33. UNIV GEORGIA  
34. ZHEJIANG SCI TECH UNIV  
35. ZHEJIANG UNIV  
36. XIAN POLYTECH UNIV  
37. KYOTO INST TECHNOL (was 22)  
38. CSIC (was 26)

Red: increase in publication activity / Blue: decrease / grey: not much change
Bibliometric Results Generated with BibTechMon™
Research Fronts in Publications until 2012 - Details

- Electronic Textiles ↑↑↑
- Nanofibers, Electrospinning ↑↑
- Plasma and Laser Treatment ↑↑
- Flame retardancy ↑
- Functional Finishing of Textiles (Antimicrobial, Super-hydrophobic, Water repellent) ↑↑
- Cleaning clothes for hospitals ↑
- Microencapsulated Phase Change Materials ↑
- Fragrant microencapsules and coating on textiles ↑↑
- Thermal function, moisture transfer, permeability: Comput. simulation, protective clothing ↑
- Cotton - genetic modif. for fiber elongation ↑↑
- Characterization of Fibers & Identification of animal fibers ↓
- Polybrominated Diphenyl Ethers (PBDEs) ↑ for flame-retardant textiles & polymers
- Jute Fibers - reinforced Polymers & chem. modification ↑
- Textile Reinforced Concrete ↑↑
- Chrysotile asbestos fibers & cancerogenicity ↑↑
- Arrows indicate if a topic shows increasing ↑, steady ↔ or decreasing ↓ research activity over the last 10 years.
Research Fronts of Functional Textiles and Fibers in Publications updated to 2015

- **Electronic Textiles**
- **Energy Harvesting, (nano)generators, triboelectric energy**
- **Plasma and Laser Treatment**
- **Flame Retardancy**
- **Functional Finishing of Textiles** (Antimicrobial, Superhydrophobic, Water repelant)
- **Microencapsulated Phase Change Materials**
- **Cyclodextrines** - finishing of cotton, wool, polyester, flax
- **Thermal function, moisture transfer, permeability**: Comput. simulation, protective clothing
- **Textile Reinforced Concrete**
- **Chrysotile asbestos fibers & cancerogenicity**
- **Carbon Nanotube Multifunctional Composite Fibers**
- **Nanofibers, Electrospinning**
- **Processing and behaviour of single polymer composites**
- **Ballistic impact on textile based body armour**
- **Forensic fiber analysis**
- **Electromagnetic shielding properties**
- **Activated carbon fiber** – cloth electrodes and absorption
- **Woven Textile Composites** (2D&3D, properties)
- **Carbon Nanoparticles for electrochromic applications**
- **Polybrominated Diphenyl Ethers (PBDEs)** for flame-retardant textiles & polymers
- **Cotton** - genetic modif. for fiber elongation
Research Fronts updated to 2015 - Details

- Electronic Textiles
- Energy Harvesting
- Plasma and Laser Treatment
- Flame Retardancy
- Functional Finishing of Textiles
- Cleaning clothes for hospitals
- Microencapsulated Phase Change Materials
- Cyclodextrines
- fragrant microencapsules and coating on textiles
- Thermal function, moisture transfer, permeability
- Characterization of Fibers & Identification of animal fibers
- Cotton - genetic modif.
- Polybrominated Diphenyl Ethers (PBDEs)
- textile components of endovascular devices, vascular prosthesis
- chrysotile asbestos fibers & cancerogenicity
- Structure & Properties of natural cellulose fibers
- Electromagnetic shielding properties
- activated carbon fiber – cloth electrodes and absorption
- Forensic fiber analysis
- Woven Textile Composites
- Exotic Fibers (Bison, Merino, Beef)
- Ceramic composites, woven SiC - properties
- textile based body armour
- Jute Fibers – reinforced Polymers & chem. modification
- Single polymer composites
- Shape Memory Polymers (SMPs)
- Metal-oxide films for electrochromic applications
- Carbon Nanotube Multifunctional Composite Fibers
- Nanofibers, Electrospinning
- Textile Reinforced Concrete
Changes in Research Fronts – new or with strong increase in research activities

- **Electronic Textiles**
  - *Supercapacitors* – carbon nanotube multifunctional fibers (superconductors & stretchable)
  - Graphene
  - *Wearable Antenna*: medical applications & firefighters
  - *Triboelectric Energy* – Energy Harvesting
  - *Electromagnetic shielding* properties

- **Functional Textiles**
  - *Cyclodextrine* Finishing
  - Increase in *antimicrobial* & *superhydrophobic* research
  - Ballistic impact on *body armour*
  - Research on *cotton genome* increased
  - Activated *carbon fiber cloth electrodes* research increased
Cyclodextrines
Top Keywords „Cyclodextrines“

- (beta-)cyclodextrin
- polycarboxylic acids
- Cotton
- citric acid
- cross-linking agents
- Fabrics/Fibers
- Parameters
- textile finishing
- polyester
- In-vitro
- Formaldehyde
- polycarboxylic acid
- polyacrylic acid
- Cellulose
- Pharmaceutical applications
- Pet prostheses
- grafting
- Manufacture
- flax fibers
- Drug release
- Ciprofloxacin
- Biological evaluation
- Water
- catalysts
- Antibiotics
- surface modification
- Polypropylene nonwoven fabrics
- Reactive filters
- Dissolution
- Drug carrier systems
- Delivery
- Durable press reagent
Most Recent Publications „Cyclodextrines“

- 2015: Finishing of polypropylene fibers with cyclodextrins and polyacrylic acid as a crosslinking agent
- 2014: Axillary odour build-up in knit fabrics following multiple use cycles
- 2013: Cyclodextrin-grafted cellulose: Physico-chemical characterization
- 2012
  - Comparative study of vascular prostheses coated with polycyclodextrins for controlled ciprofloxacin release
  - Inclusion of antibacterial agent thymol on beta-cyclodextrin-grafted organic cotton
  - Safety, Healing, and Efficacy of Vascular Prostheses Coated with Hydroxypropyl-beta-cyclodextrin Polymer: Experimental In Vitro and Animal Studies
- 2011
  - Cyclodextrin and maltodextrin finishing of a polypropylene abdominal wall implant for the prolonged delivery of ciprofloxacin
  - Methyl-beta-cyclodextrin modified vascular prosthesis: Influence of the modification level on the drug delivery properties in different media
  - Morphology and Properties of PET Fabric Finished by beta-Cyclodextrin and Citric Acid
Top Research Organisations „Cyclodextrines“

- Univ Lille 2, Lille, France
- Univ Lille 1, Villeneuve Dascq, France
- Univ Lille Nord France, F-59000 Lille, France
- Univ Maribor, SLO-2000 Maribor, Slovenia
- Univ Sci & Technol Lille, Villeneuve Dascq, France
- Univ Zagreb, Zagreb, Croatia
- Univ Alberta, Edmonton, Canada
- Ecole Natl Super Arts & Ind Text, F-59056 Roubaix, France
- CHRU Lille, F-59037 Lille, France
- CHU Nice, Nice, France
- Chalmers Univ Technol, 41296 Gothenburg, Sweden
- Text Technol Ctr, PQ J2S 1H9, Canada
Triboelectricity – Energy Harvesting
Top Keywords „Triboelectricity – Energy Harvesting“

- (Piezoelectric) nanogenerators
- Arrays
- Energy
- Driven
- Devices
- (Flexible) electronics
- Generator
- Sensor
- Composites
- Energy harvesting/ Energy harvester
- Nanorods
- Electrospinning
- Triboelectric nanogenerator
- Output
- Growth
- Fabrication
- Nanofibers
- Conversion
- Vibration
- System
- Thin-film
- Nanowire (arrays)
- Films
- Generation
- Biomechanical energy
Most Recent Publications in „Triboelectricity – Energy Harvesting“ 2014

- 3D Fiber-Based Hybrid Nanogenerator for Energy Harvesting and as a Self-Powered Pressure Sensor
- A Flexible Sandwich Nanogenerator for Harvesting Piezoelectric Potential from Single Crystalline Zinc Oxide Nanowires
- A novel investigation on carbon nanotube/ZnO, Ag/ZnO and Ag/carbon nanotube/ZnO nanowires junctions for harvesting piezoelectric potential on textile
- Analysis of junction properties of gold-zinc oxide nanorods-based Schottky diode by means of frequency dependent electrical characterization on textile
- Constructing flexible cellulose-Cu nanocomposite film through in situ coating with highly single-side conductive performance
- Direct-write PVDF nonwoven fiber fabric energy harvesters via the hollow cylindrical near-field electrospinning process
- Electrical power generation from piezoelectric electrospun nanofibers membranes: electrospinning parameters optimization and effect of membranes thickness on output electrical voltage
- Fabrication of zinc oxide nanoneedles on conductive textile for harvesting piezoelectric potential
- Flexible piezoelectric nanogenerators based on a fiber/ZnO nanowires/paper hybrid structure for energy harvesting
- Flexible thermocells for utilization of body heat
- Integration of ZnO/ZnS nanostructured materials into a cotton fabric platform
- "Novel "3-D spacer" all fibre piezoelectric textiles for energy harvesting applications"
- Piezoelectric electrospun nanofibrous materials for self-powering wearable electronic textiles applications
- Stitchable organic photovoltaic cells with textile electrodes
- Wearable thermoelectric generator for harvesting human body heat energy
Most Recent Publications in „Triboelectricity – Energy Harvesting“ 2015

- A hybrid fibers based wearable fabric piezoelectric nanogenerator for energy harvesting application
- Analysis of direct and converse piezoelectric responses from zinc oxide nanowires grown on a conductive fabric
- Cloth-Based Power Shirt for Wearable Energy Harvesting and Clothes Ornamentation
- Direct Writing of Half-Meter Long CNT Based Fiber for Flexible Electronics
- Flexible Two-ply Piezoelectric Yarn Energy Harvester
- Highly Stretchable 2D Fabrics for Wearable Triboelectric Nanogenerator under Harsh Environments
- Nanopatterned Textile-Based Wearable Triboelectric Nanogenerator
- Powerful curved piezoelectric generator for wearable applications
- Single BaTiO3 nanowires-polymer fiber based nanogenerator
- Triboelectric energy harvester based on wearable textile platforms employing various surface morphologies
- Triboelectric Generators and Sensors for Self-Powered Wearable Electronics
Top Research Organisations in „Triboelectricity – Energy Harvesting“

- Georgia Inst Technol, Atlanta, GA 30332 USA
- Linkoping Univ, Norrkoping, Sweden
- Hanyang Univ, Seoul 133791, South Korea
- Iowa State Univ, Ames, IA 50011 USA
- Sungkyunkwan Univ, Suwon 440746, South Korea
- Univ Michigan, Ann Arbor, MI 48109 USA
- Amirkabir Univ Technol, Tehran, Iran
- Univ Sci & Technol Beijing, Beijing 100083, Peoples R China
- Univ Ulm, D-89081 Ulm, Germany
- Lanzhou Univ, Lanzhou 730000, Peoples R China
- Xiamen Univ, Xiamen 361005, Peoples R China
- Korea Univ, KU KIST Grad Sch Converging Sci & Technol, Seoul 136701, South Korea
- Huazhong Univ Sci & Technol, Wuhan 430074, Peoples R China

- HSG IMIT Inst Micromachining & Informat Technol, D-78052 Villingen Schwenningen, Germany
- Ind Technol Res Inst, Elect & Optoelect Res Labs, Hsinchu 310, Taiwan
- Korea Inst Sci & Technol, Seoul 136791, South Korea
- Kwangwook Univ, Seoul 139701, South Korea
- Kyung Hee Univ, Yongin 446701, South Korea
- Chinese Acad Sci, Beijing 100864, Peoples R China

![Graph showing number of publications by country]
Download:

Bibliometric Analysis of Scientific Publications and Patents of Functional Textiles and Fibers: Overview (published 2014)

http://www.2bfuntex.eu/

For further questions:

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