



SAMPLE LANDSCAPE STUDY

Superhydrophobic Nanomaterial Coatings



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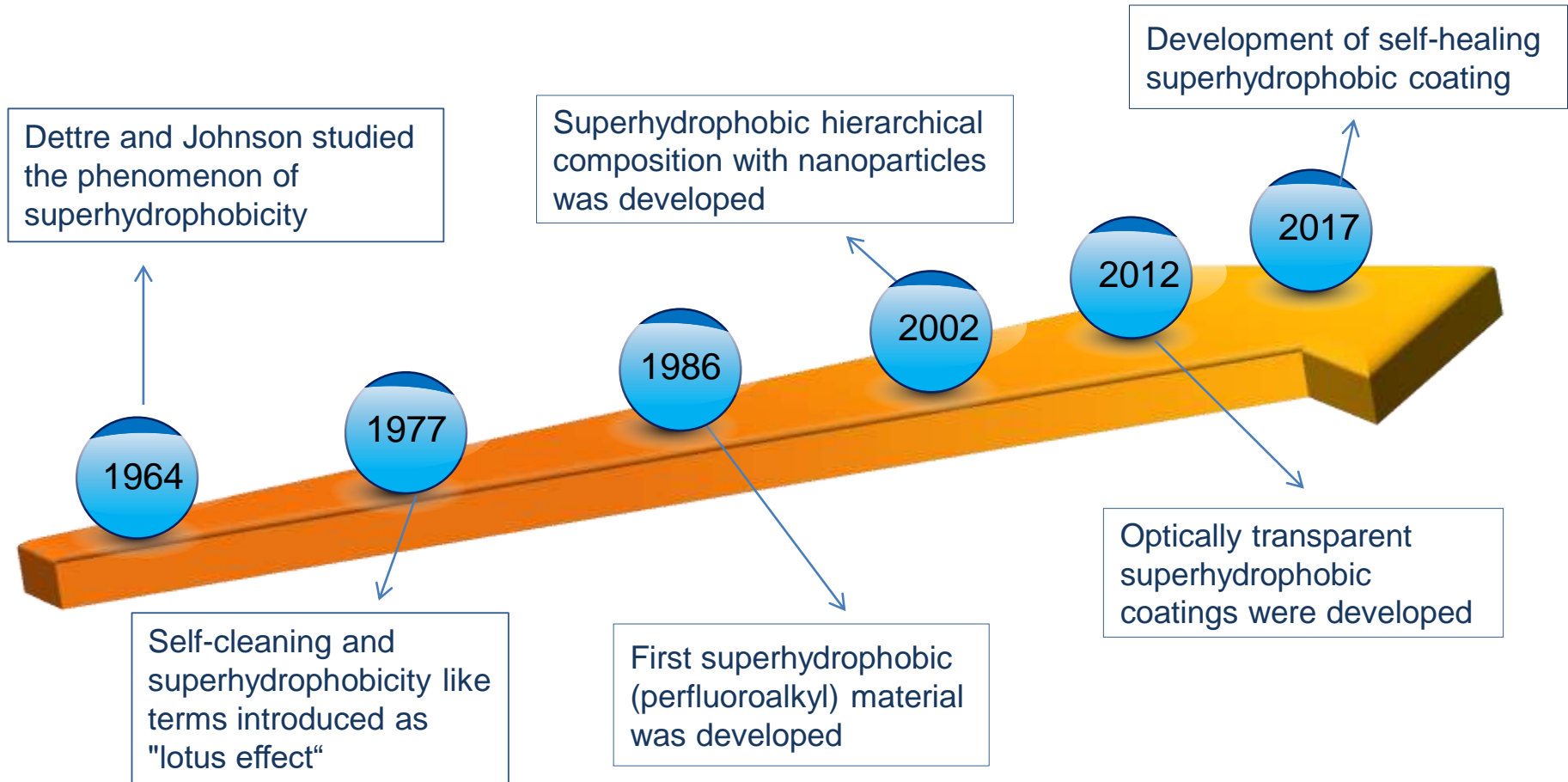
Introduction to Superhydrophobic Coatings

- A **superhydrophobic coating** is a nanoscopic surface layer that repels water.
- The term “**Superhydrophobic**” refers to a property that governs the extreme water repellence (i.e. water contact angle $>150^\circ$) and non wettability of a solid surface.
- Surface engineered nanoparticles have revolutionized the superhydrophobic coatings in a variety of substrates by formation of hierarchical rough surface morphology with micro scale materials.
- The rough surface of the superhydrophobic nanoparticles provide an intrinsic capability to repel the water droplets.
- Variety of nanomaterials like inorganic nanoparticles (metal/metal oxide nanoparticles), silica nanoparticles, graphene and carbon nanotubes etc. are widely used in combination with micro scale materials to get micro-nano hierarchical structure inspired from “**lotus leaf effect**” in making of superhydrophobic coatings.
- Superhydrophobic coatings have found many applications in industries including textiles, electronics, self cleaning surfaces in construction, agriculture, paints, military, anti-fog coating, anti-freeze surfaces, anti-bacterial surfaces, and medical applications.

Growth Prospects of Superhydrophobic Coatings

- ✓ The global superhydrophobic coatings market is estimated to witness a **CAGR of 34%** during the forecast period of 2016-2024.
- ✓ Global superhydrophobic coatings market has been driven by its application in consumer electronics, infrastructure and building industry.
- ✓ Unique properties of superhydrophobic coatings such as ultraviolet resistance, low wettability and low ice-adhesion strength is likely to stimulate superhydrophobic coatings market growth over the forecast timeframe.
- ✓ Geographically, Asia-Pacific is expected to lead the market attributing to the presence of inexpensive raw materials of optimum quality and expanding infrastructure & electronics industry.
- ✓ It is a critical time to understand the global competitive environment of superhydrophobic coatings/materials from a patent perspective and in-depth patent analysis of key technologies and players can help anticipate changes, detect business opportunities, mitigate risks and make strategic decisions to strengthen one's market position and maximize return on one's IP portfolio.
- ✓ Some of the prominent participants in the global market for superhydrophobic coatings are Beijing Neatriton Tech Co Ltd, Tianhui Waterproof Mat Co Ltd, P2i Limited, DryWired, Cytonix, Surfactis Technologies, UltraTech International Inc., NEI Corporation, Lotus Leaf Coatings Inc., PPG Industries, AkzoNobel N.V., RPM International, Inc., Sherwin-Williams Company, and Nippon Paints.

Key Developments – Superhydrophobic Materials



Objectives of the Landscape Study

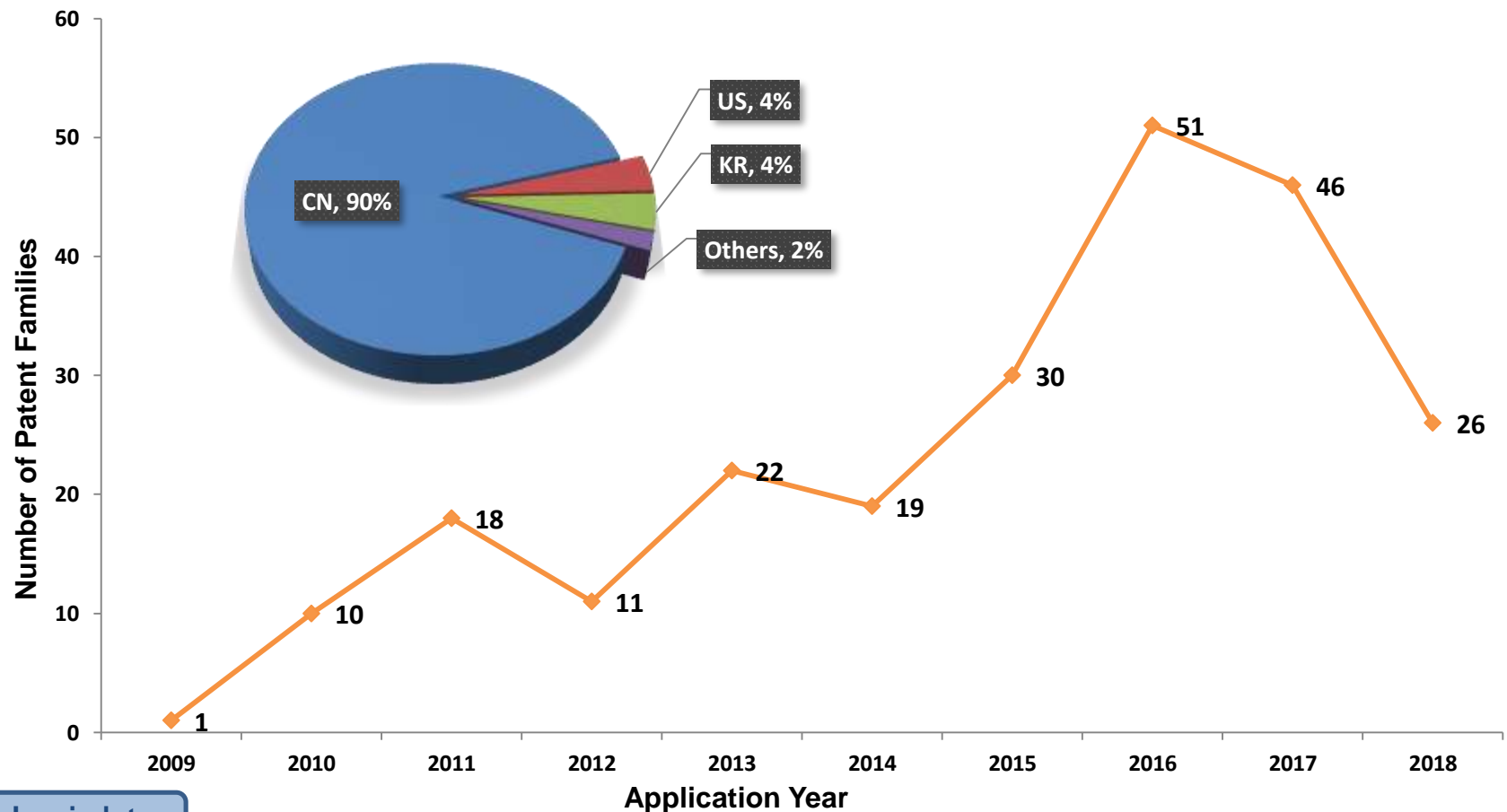
- To understand technology and prepare patent landscape
- To understand major patent holders, geographical distribution of patents, top sub-technologies based on IPC codes
- Analysis of patent filing trends over the years, top assignees, top patent classifications, among others
- To conduct Patent Portfolio based study of patents relating to core focus area of Superhydrophobic Nanomaterial Coatings
- The instant sample report provides patent analysis for Superhydrophobic Coatings for various industries like Paints, Textiles, and Electronics, which includes different types of nanoparticles used in formulations and advanced technology based patents.

Assumptions:

- The landscape study focuses on patents pertaining to superhydrophobic nanomaterial coatings filed between **2009-2018**.

Trend Analysis and Graphical Representation

Filing Trends – Last 10 Years

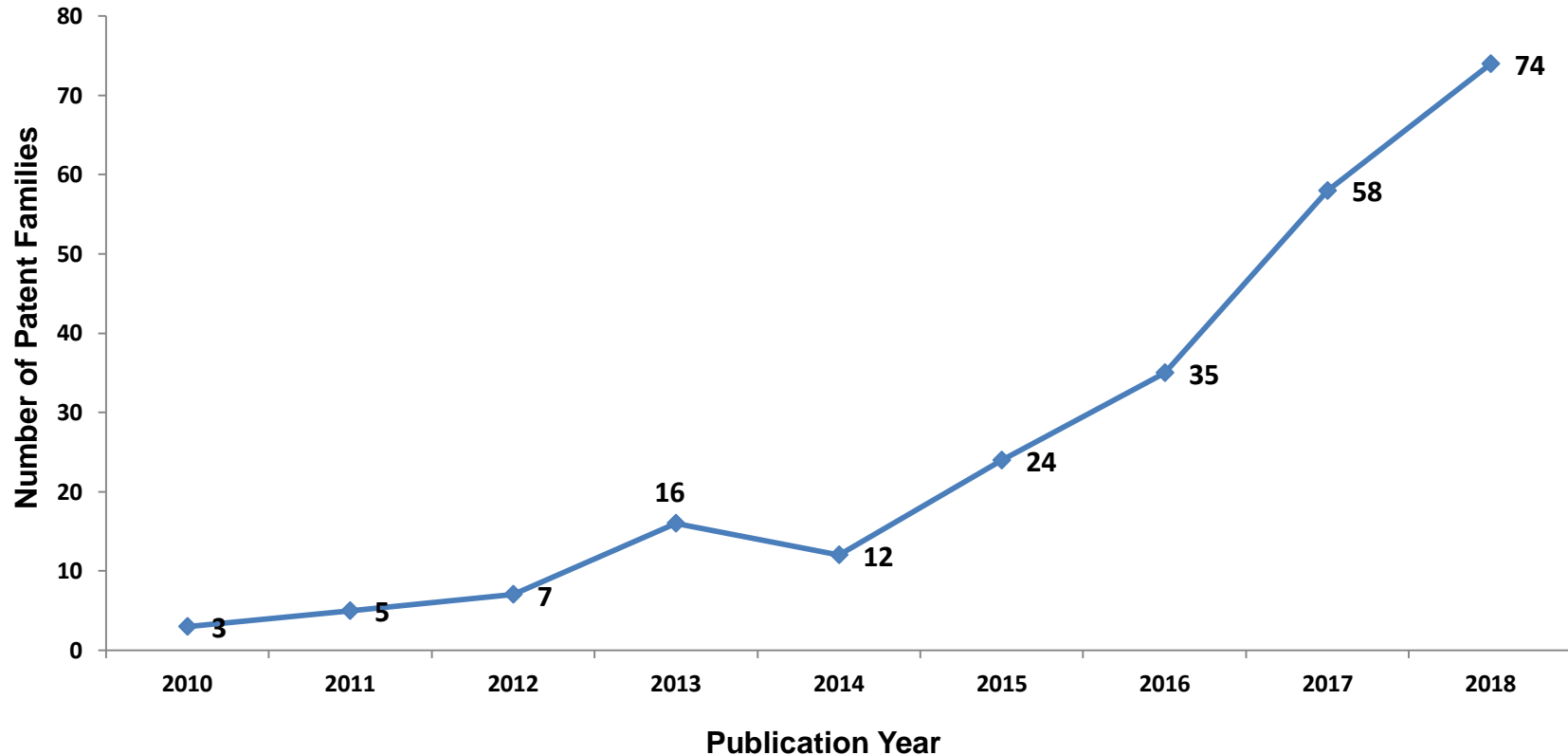


Insights

Global patent filing trend analysis shows an overall rise in the number of patent applications filed during the last 10 years. There is significant rise in the number of patents filed from the year 2015 onwards with highest filing in the year 2016. Maximum number of patent applications were filed from CN, followed by US and KR jurisdictions.

Filing trends for year 2017-2018 may be higher than that reflected in the above graph, attributed to unpublished patent applications.

Publication Trends - Last 10 Years

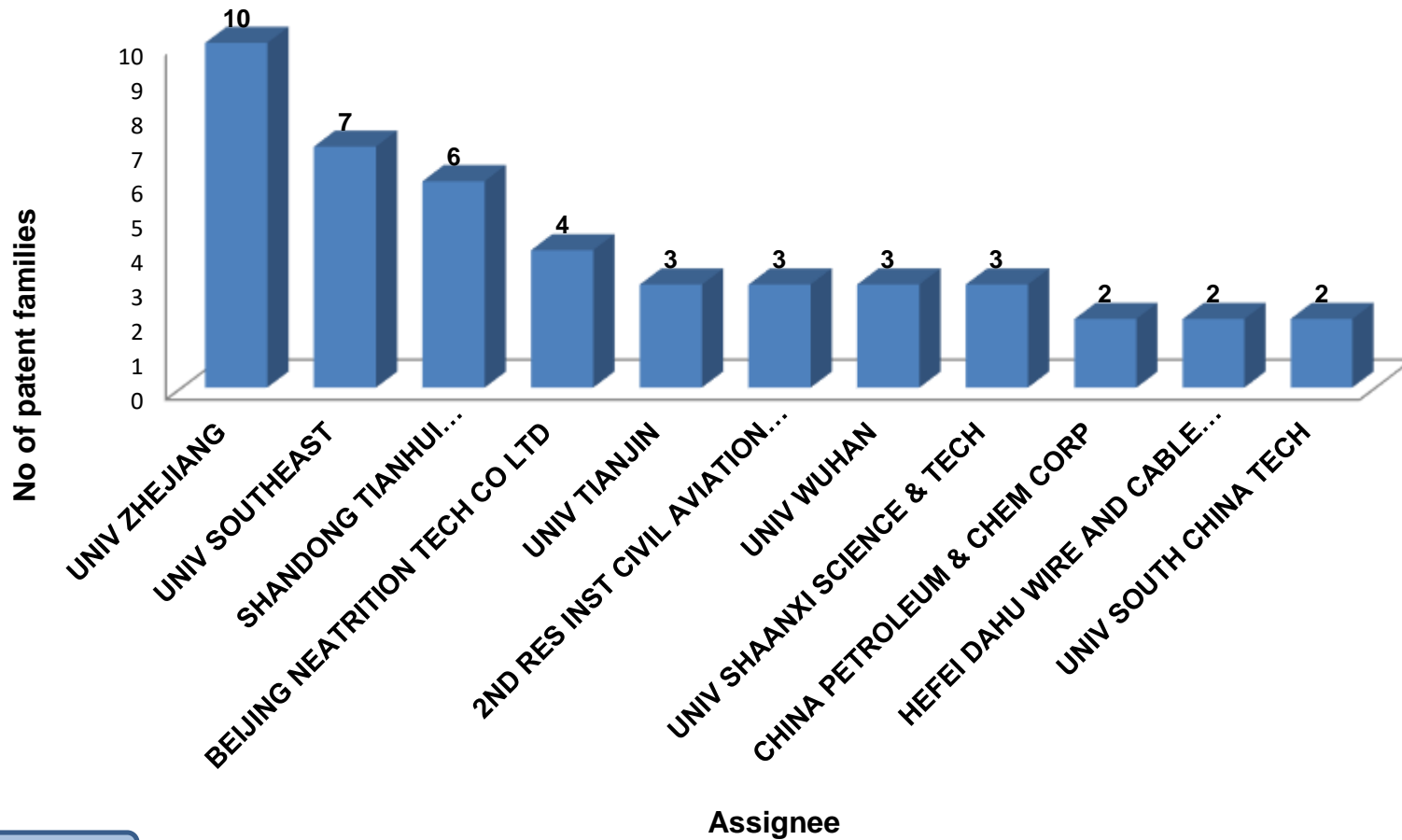


Insights

Global patent publication trend presents an overall rise in the number of patent publications during the last 10 years with its peak during 2018 suggesting significant filing during the years 2016-2017.

Graphs were prepared based on the publication year of the priority application

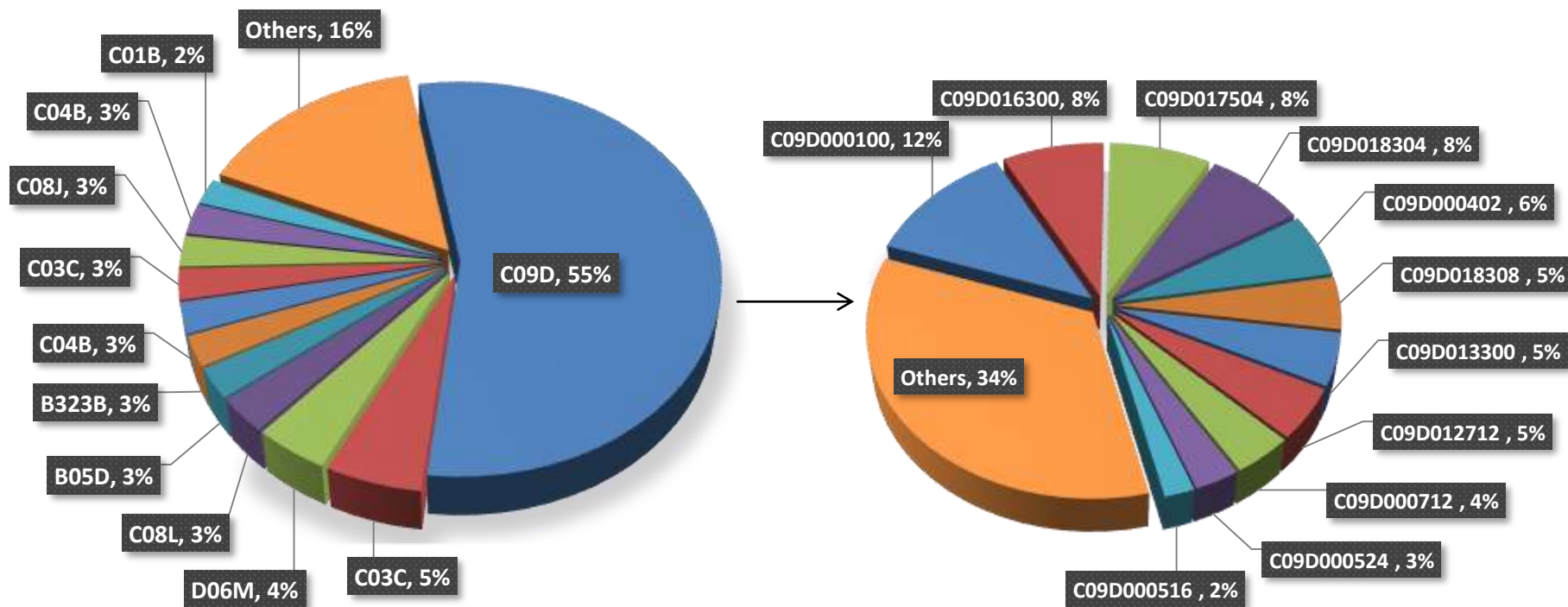
Top Assignee



Insights

Zhejiang University emerged as the leading patent applicant in superhydrophobic coatings domain followed by Southeast University and Shandong Tianhui Waterproof Co. Ltd.

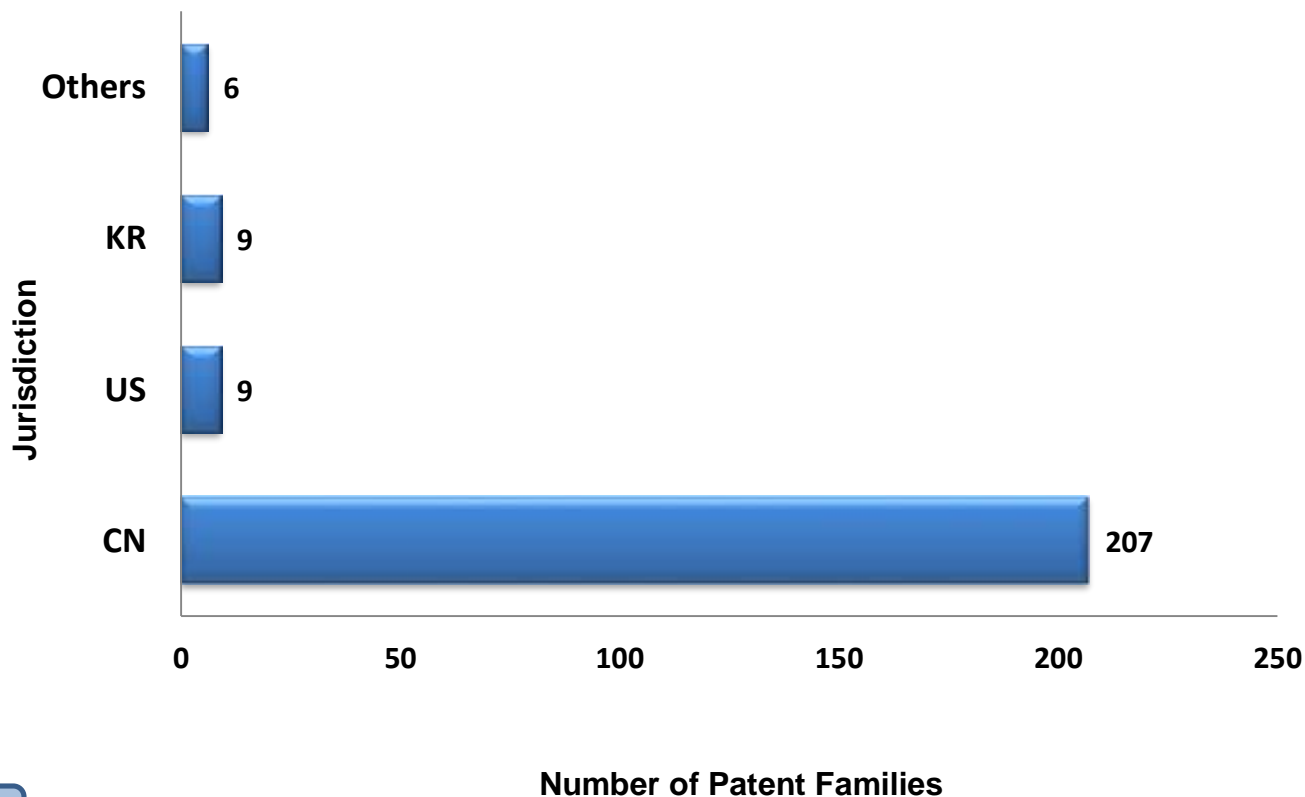
Top International Patent Classifications (IPCs)



Insights

Highest number of applications filed during 2009-2018 corresponds to IPC class **C09D** related to '**Coating Compositions, e.g. Paints, Varnishes or Lacquers; Filling Pastes; Chemical Paint or Ink Removers; Inks; Correcting Fluids; Woodstains; Pastes or Solids For Coloring or Printing; Use of Materials Therefore**', followed by **C03C** related to '**Chemical Composition of Glasses, Glazes, or Vitreous Enamels; Surface Treatment of Glass; Surface Treatment of Fibres or Filaments Made From Glass, Minerals or Slags; Joining Glass to Glass or Other Materials**', and **D06M** related to '**Treatment, Not Provided For Elsewhere In Class D06, of Fibres, Threads, Yarns, Fabrics, Feathers or Fibrous Goods Made From Such Materials**'.

Geographical Origin of Innovation



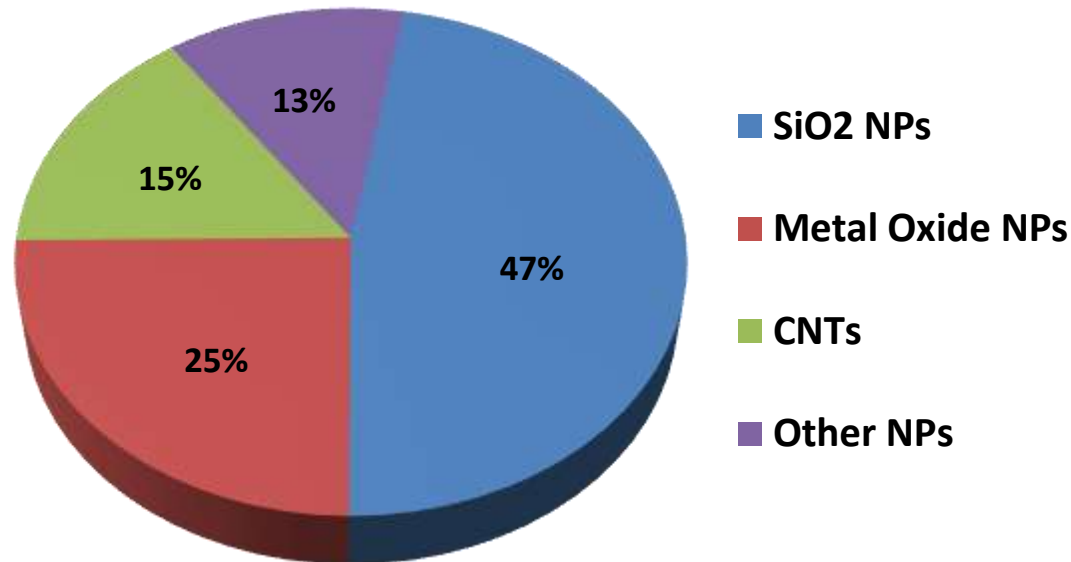
Insights

Analysis of Geographical Origin of Innovation (i.e. Priority Country) demonstrates that maximum number of innovations originated from CN followed by US and KR jurisdictions.

The graph representing Geographic origin of innovation was prepared based on the analysis of priority country member

Key Technological Trends

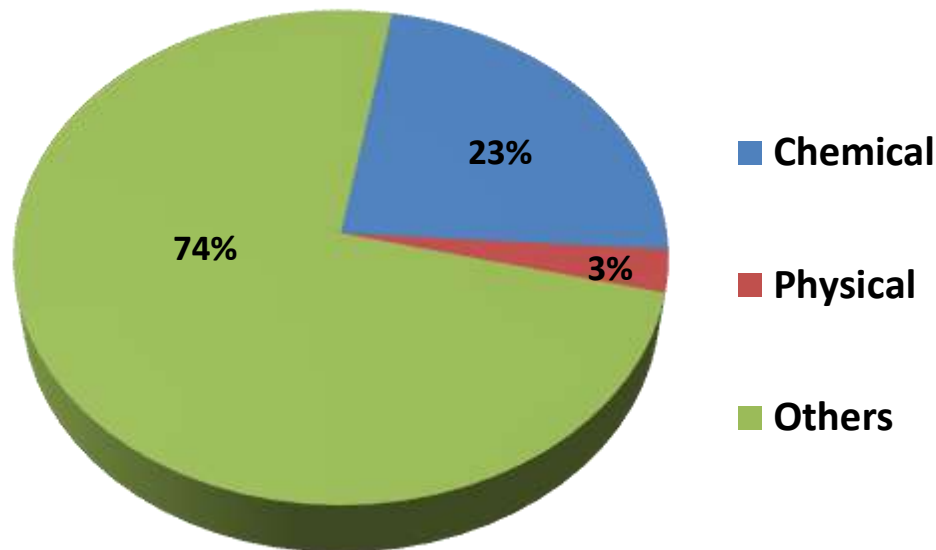
Nanomaterials Used in Superhydrophobic Coatings



Insights

Highest percentage of applications (47%) were focused on Silica nanoparticles based superhydrophobic formulations. 25% of the application featured metal oxide nanoparticles based formulations while 15% of the applications disclosed CNTs based formulations.

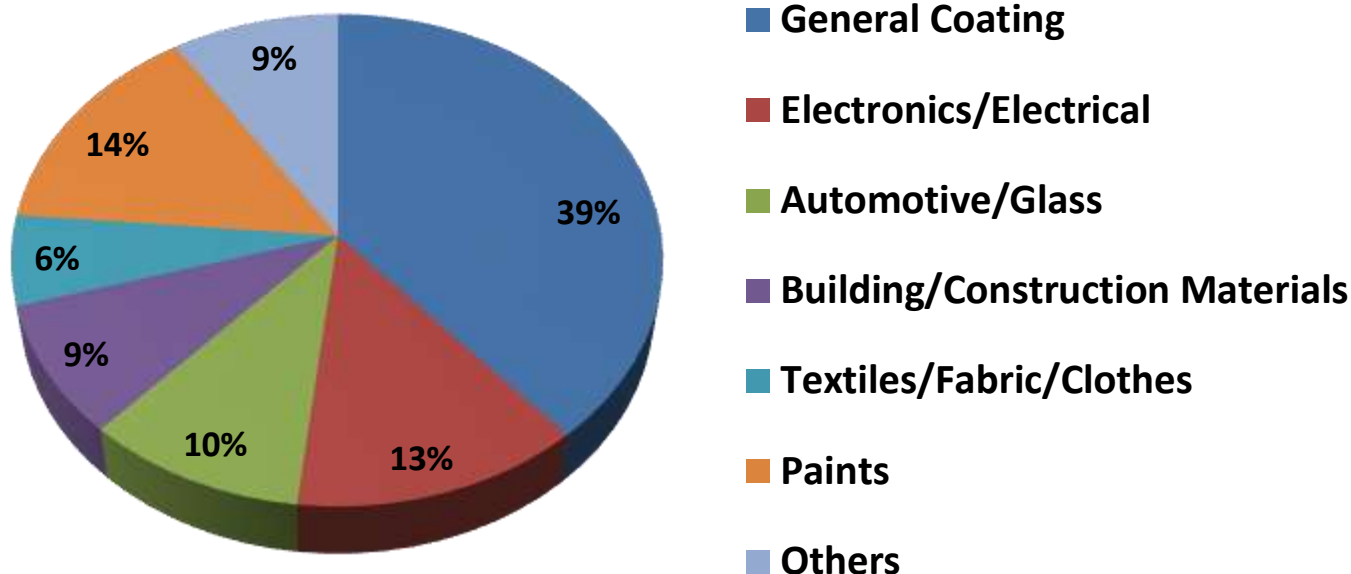
Synthesis of Nanomaterials in Superhydrophobic Coatings



Insights

Highest percentage of applications (74%) disclosed that the required nanomaterials were acquired commercially while 23% of applications disclosed use of chemical methods for the synthesis of nanomaterials.

Applications Areas of Superhydrophobic Coatings



Insights

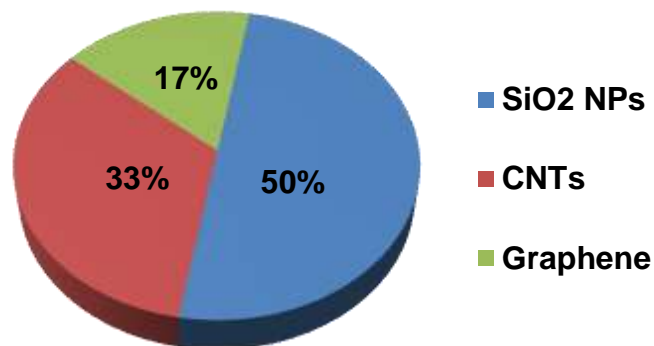
Highest percentage of applications (39%) were related to general coatings that can be used for any surface treatment. 14% of the applications disclosed use of superhydrophobic coatings as paints while 13% disclosed use as transparent coating for electronic/electrical applications followed by glass surfaces (10%), construction (9%) and textiles (6%).

Patent Portfolio Analysis

Company Profile

- Shandong Tianhui Waterproofing Co Ltd. is located in China which manufactures products with superhydrophobic nanomaterials having application in waterproofing engineering of industrial, civil and public buildings, various roofs, basements, tunnels, urban roads and bridges, metro and urban railways, high-speed railways, airports, water conservancy facilities and many other building waterproofing fields.

Nanomaterial Dissection



Application Area Dissection



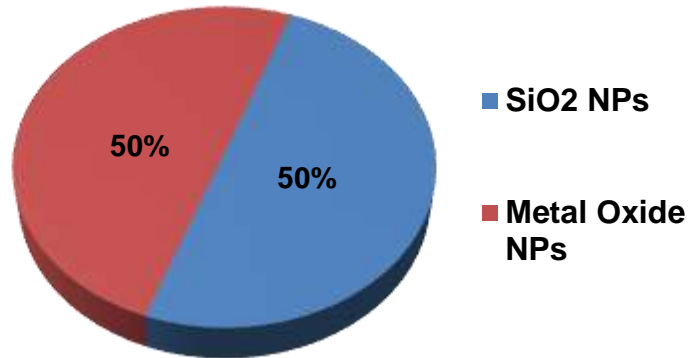
Key Patents/ Patent Publications

Patent No.	Key Features
<u>CN106348675A</u>	The patent document relates to a waterproof cement-based paint and a preparation method. The paint comprises a composition of super hydrophobic materials, a polymeric emulsion and inorganic powder. The superhydrophobic material is composed of ethylsilicate, silane, graphene, etc and prepared from a sol gel method. The emulsion is prepared from hard and soft monomers, coalescing agent, plasticizer, emulgator etc. The inorganic powder is prepared from carbon nanotubes (CNTs) and portland fly ash cement and silica sand. During preparation, the obtained super hydrophobic materials are added in emulsion polymerization, so that stability of better bonding strength, waterproofness, impact resistance and the like of the coating is achieved.
<u>CN106243840A</u>	The patent document discloses a waterproof paint and a preparation method. The paint is prepared by mixing the ultrahydrophobic material and paint composition. The ultrahydrophobic material is obtained by silanization of graphene and the paint composition is prepared from the lignin, starch, diatom ooze, and other defoaming agent and dispersing agents. The biomass raw materials and ultrahydrophobic material compensates the hygroscopic properties of the composition and the paint coating layer is endowed with more uniform and better waterproofness.

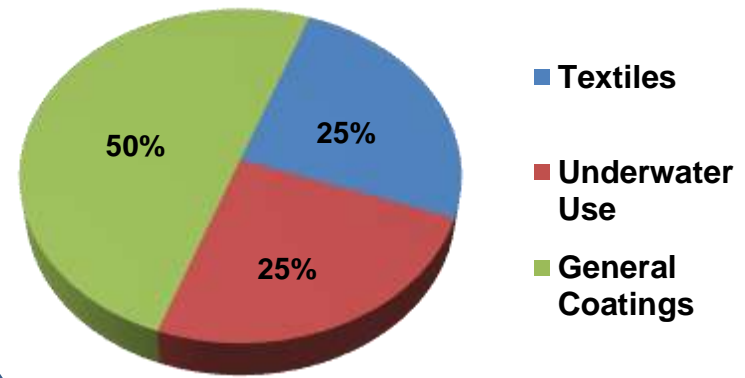
Company Profile

- Beijing Neatriton Technology Co. Ltd. is a China based materials and technology company and is a forerunner of the industrialization of superhydrophobic technology.
- It manufactures products mainly designed with superhydrophobic nanomaterials which are waterproof, dustproof, snow proof and oil proof.

Nanomaterial Dissection



Application Area Dissection



Key Patents/ Patent Publications

Patent No.	Key Features
<u>WO2018090420A1</u>	The patent document discloses preparation method of a transparent super hydrophobic coating layer. The coating is composed of hydrophobically modified metal oxide nanoparticles, active auxiliary, ammonia-modified nanoparticles and organic solvents. A certain cross link is formed between the nano particles and substrate through the auxiliary thereby improving the overall adhesion of the coating.
<u>CN105647290A</u>	The patent document discloses a super-hydrophobic material which can be used for underwater application and its preparation and application method. The super-hydrophobic coating is formed by a backing material and a hydrophobic material. Hydrophobic material comprises inorganic nanoparticles, silane coupling agent, catalyst and an organic solvent. The backing material is prepared from rubber, petroleum resin, flatting agent and organic solvent. The backing material and the hydrophobic material are used in combination and the backing material is utilized for increasing the direct bonding strength of a super-hydrophobic coating onto a base material.

Analysis of Key Granted Patents/Patent Applications Assigned to Educational Institutes and Other Companies

Granted Patents/Patent Applications – Institutes & Universities

Patent No.	Key Features
CN107384055A South East University	The patent document discloses a method of preparing a durable superhydrophobic coating which comprises ultrasonic dispersion of hydrophobic silica or metal oxide nano particles , a hydrophobic resin and curing agent in a volatile organic solvent under mechanical agitation conditions to get an hybrid coating. The coating is suitable for various common base material surfaces such as metal, glass, timber and concrete, the equipment is simple, operation is easy, the cost is low.
CN106398334A South East University	The patent document discloses a wear-resisting super-hydrophobic coating and its preparation method. The coating is prepared by dispersing of fumed silica nanoparticles in polyether polyol resin and 2,4-toluenediisocyanate and applying to the surface of a substrate by brushing or spraying or dipping and naturally drying. The preparation method has the advantages that the equipment and process are simple, operating is easy, and the cost is low; and have industrial scale production prospect. The super-hydrophobic coating prepared herein features high bonding force and high hardness and is applicable to the fields, such as building, shipping, naval craft, aircrafts, automobiles, high-speed railway, and wind generators.
CN106519744A South East University	The patent document provides a simple low cost large scale production method a carbon nanotube super-hydrophobic coating. The method comprises ultrasonically dispersing multiwall carbon nanotubes containing hydroxyl in an isopropanol solution, and adding ammonia water and deionized water drop by drop on stirring and add tetraethoxysilane. After a period of time, a silane solution is added to obtain the final MWCNT coating solution which can be spray dried on to surface to get the carbon nanotube super-hydrophobic coating. The solution can be used to treat any kind of surface to obtain self-cleaning, anti-pollution, anti-corrosion properties.

Granted Patents/Patent Applications – Institutes & Universities

Patent No.	Key Features
CN108117833A Zhejiang University	The patent document discloses a titanium dioxide/polymer composite dielectric hydrophobic material and its preparation method. The method involve the blending of TiO ₂ nano wires through polydimethylsiloxane polymer matrix wherein the TiO ₂ acts as a filling material and accounts for 5 to 30 % of the total mass of the hydrophobic material. The TiO ₂ nanowires are prepared by a hydrothermal method and the diameter is about 100 nanometers and the length is about 8 microns. A composite film with uniformly dispersed titanium dioxide can be prepared by applying the titanium dioxide nanowire to a solution blending and spin-coating process.
CN108047916A Zhejiang University	The patent document discloses a preparation method of super-hydrophobic coating and the method comprises that a hybridized siloxane and fluorine-containing siloxane are added to a ultrasonic solution of inorganic nano particles in ethyl alcohol and water. The pH is adjusted by adding 25 v% ammonium hydroxide. The obtained mixed sol and waterborne polyurethane (WPU) emulsion are mixed with the obtained solution and the reaction is performed for 0.5-1 hr under the temperature of 20-30 deg C to get the super hydrophobic coatings and particularly applicable to textile treatments.
CN105602297A Tianjin University	The patent document discloses a method for preparing a superhydrophobic coating through composite of inorganic nano-particles with different average particle sizes. The inorganic nano-particles are hydrophobically modified with a silane coupling agent in the mixed dispersion and acts as a super hydrophobic coating layer on various soft and hard substrates through extraction, spraying, drop-coating, spin-coating.

Granted Patents/ Patent Application – Other Companies

Patent No.	Key Features
CN106947334A Xerox Corporation	The patent document provides a superhydrophobic nano-fabrics and coatings and a preparation method. The method include providing a dispersion either single walled or multi walled carbon nanotubes, a stabilizer, a hydrophobic polymer, and a solvent. The dispersion is applying to a particular region of the fabric and heating the fabric to become hydrophobic of water contact angle of at least about 120 degrees.
CN201648821U Rixin Textile Co Ltd	The patent document provides a cotton superhydrophobic coating fabric in that the two surfaces of the cotton fabric are coated with silica nanoparticle layers covered by a hydrophobic fluorinated quaternary amine silicane couplant. The combination of the silica nanoparticle and the hydrophobic fluorinated quaternary amine silicane couplant allows gas molecules rather than the water molecules which can pass through the fabric so that the fabric has water-repellent and gas-permeable effect and makes a user feel comfortable.

Appendix 1: Sources

- [Recent advances in superhydrophobic nanomaterials and nanoscale systems](#)
- <https://www.gminsights.com/industry-analysis/superhydrophobic-coating-market>
- <https://globenewswire.com/news-release/2018/09/28/1586319/0/en/Hydrophobic-Coatings-Market-to-cross-2-bn-by-2024-Global-Market-Insights-Inc.html>
- <https://www.nanoshel.com/product/nano-super-hydrophobic-coating>
- <https://pubs.rsc.org/en/content/getauthorversionpdf/C3NR05380F>
- [https://www.sandia.gov/research/research_development_100_awards/assets/documents/2008_winners/Superhydrophobic SAND2008-2215W.pdf](https://www.sandia.gov/research/research_development_100_awards/assets/documents/2008_winners/Superhydrophobic_SAND2008-2215W.pdf)
- [https://www.researchgate.net/publication/280115341 Superhydrophobic materials and coatings A review](https://www.researchgate.net/publication/280115341_Superhydrophobic_materials_and_coatings_A_review)
- <https://link.springer.com/article/10.1007/s11998-017-0011-x>
- <https://en.wikipedia.org/wiki/Ultrahydrophobicity>
- <https://www.businesswire.com/news/home/20180920005942/en/Latest-Developments-Superhydrophobic-Coatings-Emission-Coatings-Anti-bacterial>
- <http://www.texshield-project.eu/>
- <http://www.neatrition.com/en/>
- <http://en.sdthfs.com/>

Appendix 2: Definition of IPC Classes

IPC CLASS	DEFINITIONS
C09	DYES; PAINTS; POLISHES; NATURAL RESINS; ADHESIVES; COMPOSITIONS NOT OTHERWISE PROVIDED FOR; APPLICATIONS OF MATERIALS NOT OTHERWISE PROVIDED FOR
C09D	COATING COMPOSITIONS, E.G. PAINTS, VARNISHES OR LACQUERS; FILING PASTES ; CHEMICAL PAINT OR INK REMOVERS; INKS; CORRECTING FLUIDS; WOODSTAINS; PASTES OR SOLIDS FOR COLOURING OR PRINTING; USE OF MATERIALS THEREFOR
C09D 01/00	COATING COMPOSITIONS, E.G. PAINTS, VARNISHES OR LACQUERS, BASED ON INORGANIC SUBSTANCES
C03	GLASS; MINERAL OR SLAG WOOL
C03C	CHEMICAL COMPOSITIONS OF GLASSES, GLAZES, OR VITREOUS ENAMELS; SURFACE TREATMENT OF GLASS; SURFACE TREATMENT OF FIBRES OR FILAMENTS MADE FROM GLASS, MINERALS OR SLAGS; JOINING GLASS TO GLASS OR OTHER MATERIALS
D06	TREATMENT OF TEXTILES OR THE LIKE; LAUNDERING; FLEXIBLE MATERIALS NOT OTHERWISE PROVIDED FOR
D06M	TREATMENT, NOT PROVIDED FOR ELSEWHERE IN CLASS D06, OF FIBRES, THREADS, YARNS, FABRICS, FEATHERS OR FIBROUS GOODS MADE FROM SUCH MATERIALS

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