Technology Scouting: Water Purification

The following report presents the technological landscape in the water purification market. The report uses financial deals and patent data to identify major technologies in water purification. In this process, major companies, startups and universities in each technology in water purification are also identified. Some companies have been profiled for their financials and their work in water purification market. Some of the research going on in major universities in the field of water purification has also been detailed out.

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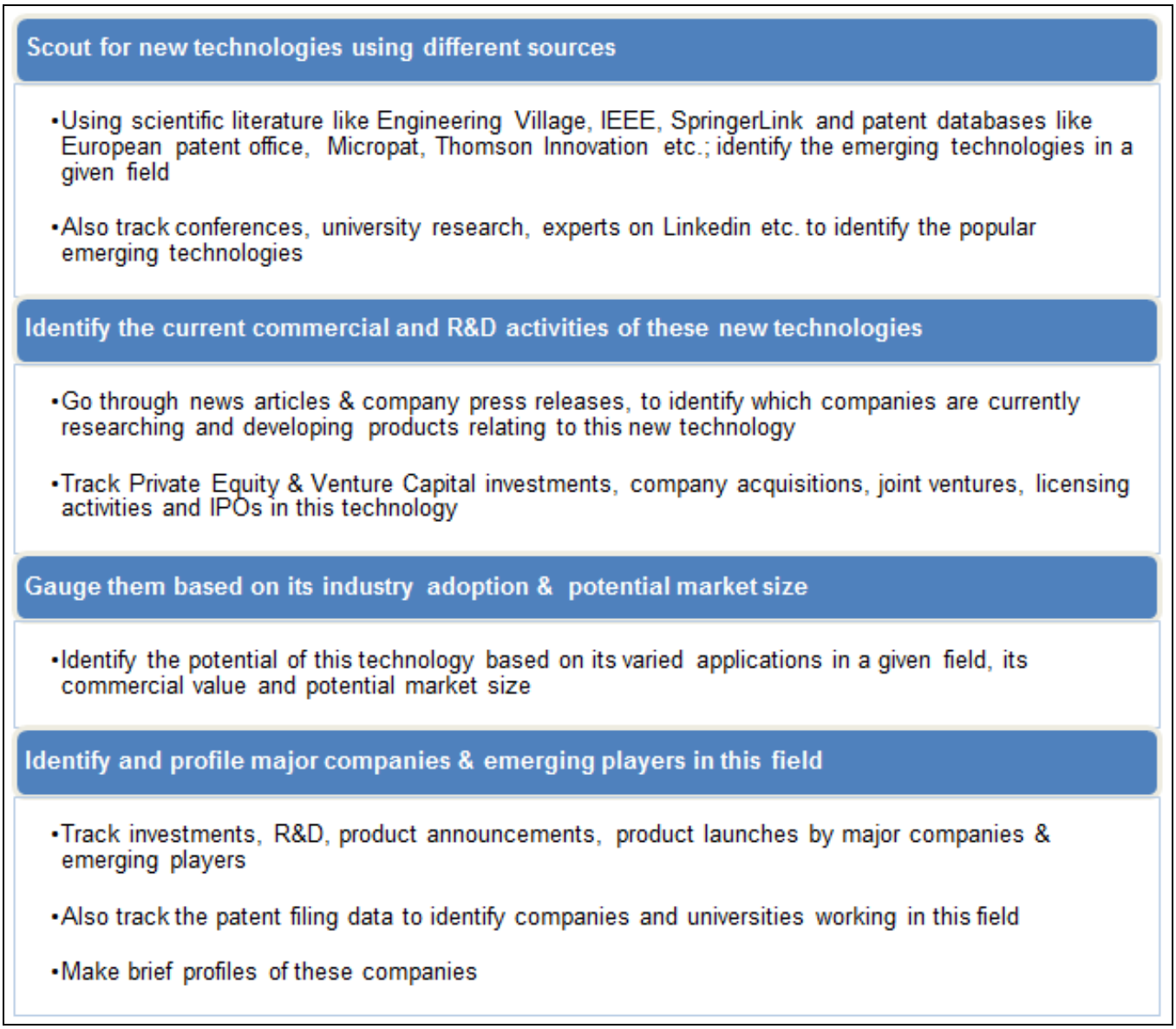
Objective of the Report

The objective of the report is to

- identify major technologies in water purification market using financial market activities
- understand the investment landscape in water purification
- identify major companies, start-ups and university research in the Nanofiltration segment of water purification

Research Methodology

The methodology followed to achieve the above listed objectives is given below:



Scope of the Report

The report covers financial market activity only in the last 3 years (2009-2012)

Introduction to Water Purification

Water purification is the process of removing contaminants from surface water or groundwater to make it fit for specific purposes. The contaminants may be particulate matter, dissolved minerals or microorganisms. Technologies commonly employed to purify water are distillation, ion exchange, adsorption, filtration, membrane filtration, ultraviolet (UV) radiation or a combination of more than one of these. The technologies most applied currently are membrane filtration and UV radiation. Nanotechnology is significantly advancing water purification technologies, especially in membrane processes.

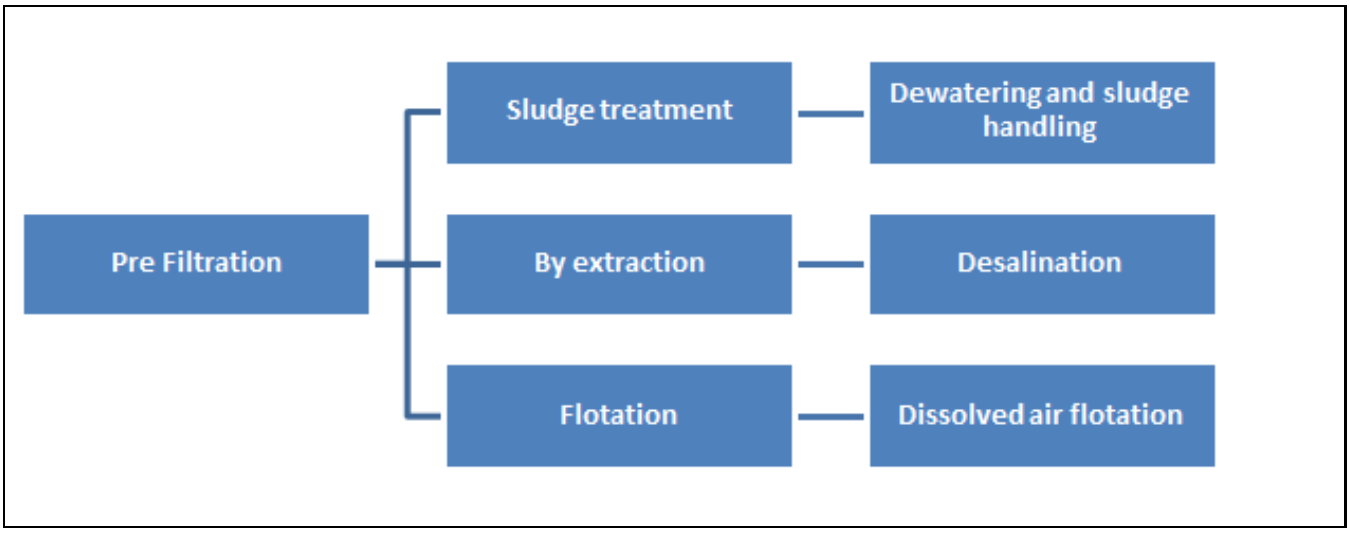
Technical Classification

The following technical classification has been arrived at, based on its commercial usage and popularity.

Note: Please note that the classification is only an indicative of the water purification market. It is not an exhaustive classification of water purification techniques.

Pre Filtration

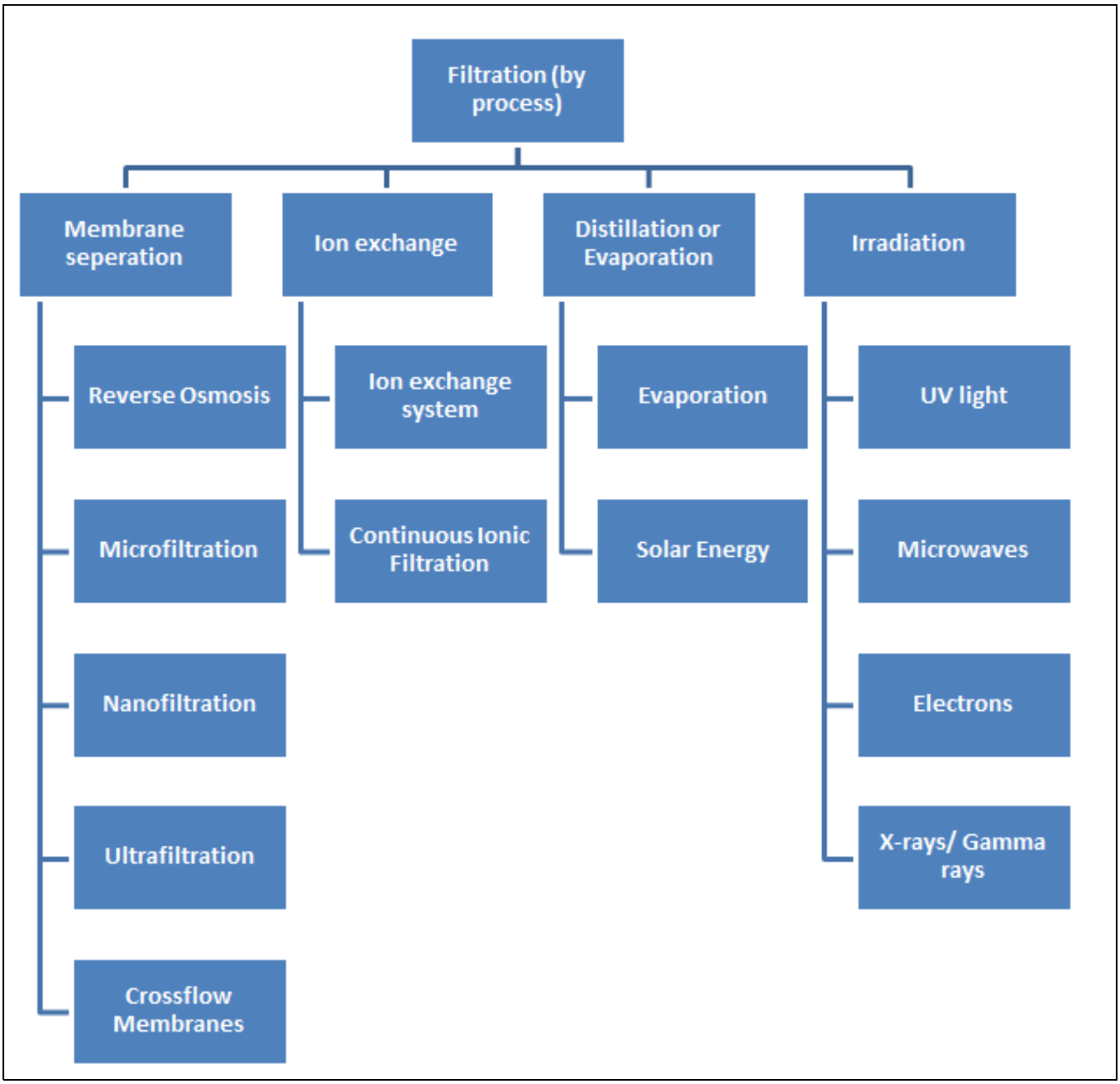
The technical classification for pre-filtration techniques is as follows:



Source: European Patent Office

Filtration (by process)

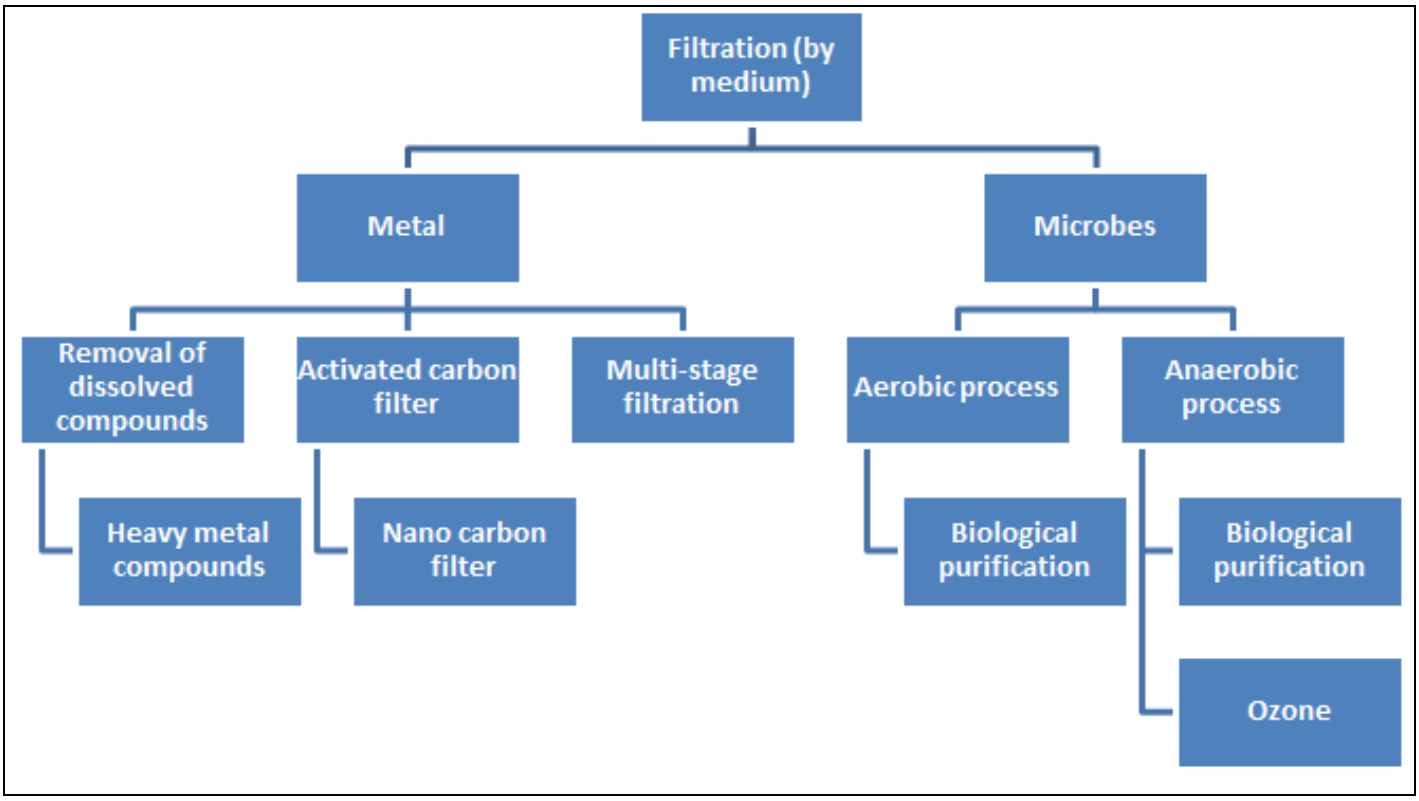
The technical classification for filtration techniques by process-type is as follows:



Source: European Patent Office

Filtration (by medium)

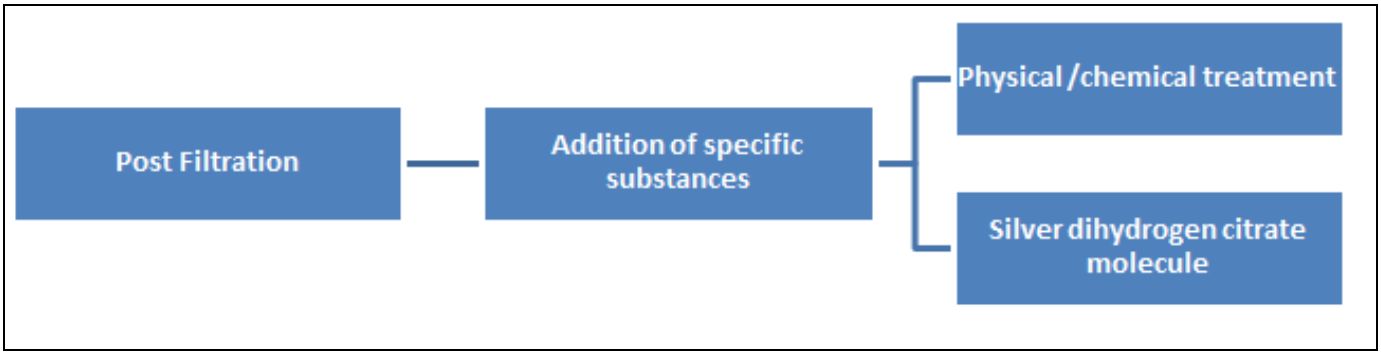
The technical classification for filtration techniques by medium is as follows:



Source: European Patent Office

Post Filtration

The technical classification for post-filtration techniques is as follows:



Source: European Patent Office

From here on, the report will focus only on Filtration techniques.

Financial Landscape Snapshot

The following dashboard illustrates the Investment Landscape in various technologies of Water Purification:

This is supposed to be a flash animation. You'll need the flash plugin and a browser that supports it to view it.

Source: Cleantech

Detailed Technology-wise Financial Activities

This section details out the financial activities in the last 2 years in the water purification market.

Membrane Separation

This section details out the financial activities in the last 2 years in the membrane separation segment.

Venture Capital Investments

The following table shows the venture capital investment activity in detail for membrane separation.

Investor Company	Description	Invested company	Invested technology	Invested Amount	Sources
Dow Chemical Company	With annual sales of $54 billion and 46,000 employees worldwide, Dow is a diversified chemical company that combines the power of science and technology with the " Human Element " to constantly improve what is essential to human progress. The Company delivers a broad range of products and services to customers in around 160 countries, connecting chemistry and innovation with the principles of sustainability to help provide everything from fresh water, food and pharmaceuticals to paints, packaging and personal care products.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
Sail Venture Partners (SAIL)	SAIL Venture Partners, L.P. is a national venture capital firm with offices in Southern California and Washington, D.C., investing in early-stage companies primarily in the Energy/Cleantech sector. The SAIL partners invest through two primary funds, which focus on clean technologies in the areas of alternative energy, water, agriculture and materials.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
International Finance Corporation (IFC)	International Finance Corporation is a private equity and venture capital arm of World Bank specializing in both direct and fund investments. It seeks to invest in early stage companies.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$15 million	Waterhealth
Liberation Capital	Liberation Capital is a Global Private Equity Fund providing finance for small renewable energy, water and waste water projects. Their investment model centers on strategic partnerships with CleanTech technology firms and project developers with multi-project/multi-year investment horizons.	Desalitech, Ltd	Reverse osmosis (Closed Circuit Desalination technology)	$6.25 million	Businesswire
One Equity Partners LLC	One Equity Partners makes private investments in a variety of industries including chemicals, healthcare, technology, travel and manufacturing	Sud-Chemie AG	Reverse osmosis (NITREA process and PAni technology	$1433.5 million	Sud-chemie
Danish Business Innovation Fund	The Business Innovation Fund is an official government initiative established in autumn 2009 under the Danish Ministry of Economic and Business Affairs. The aim is to develop innovative commercial products and services that can meet the increasing global demand for green solutions and welfare as well as generate growth and employment in Denmark.	Aquaporin A/S	Membrane technology	$1.39 million	Aquaporin
SAS Investors	SAS Investors targets companies that provide solutions based on technology emerging out of tech transfer centers, universities, and/or corporate labs in which a subject matter expert has developed unique IP that is particularly relevant to industry pain points	HydroGlobe. Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	$1.1 million	Poodyglitz

Private Equity Funding

The following table shows the private equity funding in detail for membrane separation.

Company	Technology focus	Deal type	Funder/Company	Technology invested in	Funding Amount	Geography	Other Details
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency	Funding	Undisclosed Investors	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$22.5 million	United States	Received in the 1st Quarter of 2012

	relief units.						
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	Dow Venture Capital (Dow) and Sail Venture Partners (SAIL)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	more than $10 million	United States	WHI has more than 600 installations of its water purification and disinfection systems in developing countries around the world. This additional funding further strengthens WHI and will allow for accelerated growth.
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	International Finance Corporation (IFC)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$15 million	United States	The facility is in the form of long term loans to help more than 600 communities in India fund the purchase of WaterHealth Centres over the next 18 months, with the capacity to serve more than three million people.
Desalitech, Ltd	Desalitech, Ltd. is engaged in the development and commercialization of closed circuit reverse osmosis desalination technologies for the applications of sea water desalination, brackish water desalination, industrial water upgrade, and wells water purification	Private Equity (Direct Investment)	Liberation Capital	Reverse osmosis (Closed Circuit Desalination technology)	$6.25 million	Israel	Desalitech will use the funding to expand its business and working capital
Sud-Chemie AG	Sud-Chemie AG is a Germany-based group engaged in the manufacture of specialty chemicals. It operates through two divisions: Catalysts and Adsorbents. The products manufactured by the Catalysts division offer solutions for water treatment, petrochemicals processing, energy storage and hydrogen production, as well as off-gas purification. The key markets served by its Adsorbents division include the consumer-goods, packaging and foundry industries, as well as the paper and plastics industries	Private Equity (Exit)	One Equity Partners LLC	Reverse osmosis (NITREA process and PAni technology	$1433.5 million	Switzerland	The transaction will enable Clariant to expand in chemical catalysts used in the oil and automotive industries
Aquaporin A/S	Developer of technology for water purification and desalination of seawater	Venture Financing	Danish Business Innovation Fund	Membrane technology	$1.39 million	Denmark	The main strategy is to develop the Aquaporin Inside? technology capable of separating and purifying water from all other compounds. Primary market focus includes ultra pure water (UPW) used in extreme applications such as medico, biotech, in the production of semiconductors and flat panels and other industrial purposes. Secondary market focus includes desalination of seawater and

							pressure retarded osmosis applications.
HydroGlobe. Inc	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative and affordable water-purification technology to municipalities and consumers	Venture Financing	SAS Investors, New Product Development Consortium, Stevens Institute of Technology	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	$1.1 million	United States	The funds raised would facilitate Hydroglobe to build a market presence for MetSorb, its new filter media for Arsenic removal, and to hire the work force needed to sell and implement its equipment solutions.

Mergers and Acquisitions

The following table shows the mergers and acquisitions in detail for membrane separation.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Graver Technologies	Designs, develops, and manufactures products that facilitate and enhance separation, purification, and process filtration	Acquisition	HydroGlobe, Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	Undisclosed	United States	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative and affordable water-purification technology to municipalities and consumers
Grundfos Holding A/S	Grundfos Holding A/S is a manufacturer of pumps. The company?s products include circulator, submersible, and centrifugal pumps. It serves agriculture, automotive, biofuel, food, agricultural water distribution, agricultural water treatment, beverage, commercial buildings, and HVAC OEM sectors	Acquisition	Enaqua	Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis (RO), UV disinfection	Undisclosed	United States	The acquisition will allow Grundfos to obtain new technology and competence as a strong supplement to its existing business and enable to deliver new solutions for water treatment with strengthened focus on sustainability. Enaqua is a provider of an environmentally friendly advanced purification solutions. The company has developed ultraviolet disinfection equipment based on Activated Fluoropolymer Technology (AFP?). It manufactures non-contact disinfection systems and membrane systems.
Undisclosed	An investor group, has acquired an equity stake in excess of 5% in WaterHealth International, Inc., a provider of water treatment solutions based on water purification and disinfection technology. Both the entities are based in the US	Acquisition	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	5% stake	United States	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units
Pentair, Inc	Diversified industrial manufacturing company	Acquisition	Clean Process Technologies (CPT) division on Norit	Activated carbon, Membrane Filtration,	$716.4 million	Netherlands	CPT is a provider of membrane solutions and clean process technologies for water

			Holdings B V				and beverage filtration and separation segments CPT provides components, systems, and services that are expected to broaden and deepen Pentair?s capabilities in desalination, water reuse and high efficiency industrial applications and enable Pentair to provide more integrated solutions to its customers. The acquisition is also expected to strengthen Pentair in the food and beverage sector and in fast growth regions, including China, Latin America and the Middle East
Salcon Berhad	Malaysia-based designer, constructor, operator and maintainer of water treatment plants and water works	Acquisition	Darco Environmental Pte., Ltd	membrane and ion-exchange technologies (organic and inorganic treatments, membrane filtration and separation, electro-winning, chemical precipitation and vacuum degasification)	$15.17 million	Singapore	Darco Water Technologies (Darco) is involved in designing, fabricating, assembling, installing and commissioning engineered water purification and wastewater treatment systems. The group also provides water management services like maintenance of filters; maintenance of ion exchange resin columns; and operation and maintenance of engineered water systems. The group operates in Singapore, Malaysia, the Philippines, Indonesia, Taiwan and China. It is headquartered in Singapore City, Singapore.The group recorded revenues of S$69.7 million (approximately $51.2 million) in the fiscal year ended December 2010. Its net profit was S$1.3 million (approximately $1 million) in fiscal 2010.
Siemens Industry Automation Division	Siemens Industry Automation Division is a provider of a complete and integrated line of products, systems, and solutions for production and process automation for manufacturing industries, process and basics industries, and research, development, and training centers	Acquisition	Cambridge Water Technology, Inc	CoMag, a solid and precipitated particulate removal process based on the process of coagulation, flocculation, and clarification that produces effluent equivalent to ultra-filtration; and BioMag, a retrofit application that enhances the performance of biological treatment systems, increases capacity, catalyzes biological productivity, and produces effluent for activated	Undisclosed	United States	The acquisition will strengthen the Siemens product portfolio with technologies for advanced water and wastewater treatment Cambridge Water Technology, Inc. is engaged in providing municipal and industrial wastewater treatment facilities.

				sludge plants needing treatment capacity or enhanced nutrient removal capability			
Pall Corporation	Supplier of integrated filtration, separation and purification technologies	Acquisition	Engefiltro	Absolute filtration, microfiltration, ultrafiltration, Reverse Osmosis, Coalescers Liquid / Liquid	Undisclosed	Brazil	The transaction will strengthen Pall?s regional capabilities in the design, construction and servicing of sophisticated fluid management systems for customers in the life sciences and industrial markets throughout Latin America. Engefiltro is a distributor of mining, oil and gas, chemical and petrochemical, power generation, food processing and pharmaceutical products
Seprotech Systems Incorporated	Seprotech Systems is an environmental technology company engaged in the manufacture and sale of water and wastewater treatment systems. The company offers packaged systems including industrial membrane systems, mobile response package plants, purification equipment, rotating biological contactors, wastewater treatment and water treatment equipment. In addition, it offers industrial solutions such as microfiltration, nano filtration, reverse osmosis, ultra filtration; and water and wastewater treatment solutions. The company primarily operates in Canada, where it is headquartered in Ottawa.	Acquisition	WESA Group	Aerobic and anaerobic biological, Physical / chemical treatment, Dissolved air flotation, Media Filtration, Activate carbon adsorption, Enhanced Oxidation, Dewatering and sludge handling, Ion exchange, Reverse osmosis, Ultrafiltration and microfiltration, Evaporation	$2.03 million	Canada	With this acquisition, Seprotech will become a major provider of earth sciences, water resources and environmental engineering services, and wastewater/water treatment systems. The combined entities will be able to provide their clients with a much broader spectrum of professional services and complete systems to solve their problems and WESA will have a platform for much more rapid growth.
Tri-Tech Holding, Inc.?s subsidiaries Tri-Tech International Investment, Inc. and Tri-Tech Infrastructure, LLC	Tri-Tech Holding is a China-based designer of customized sewage treatment and odor control systems	Acquisition	J&Y International, Inc	Evaporators, reverse osmosis, filtration, ion exchange, biological, physical and chemical methods	$1.5 million in cash and Tri-Tech stock	United States	With this acquisition, Tri-Tech will have the technology to expand into the markets for seawater desalination, water reuse, and zero liquid discharge (ZLD), driven by increased scarcity of water resources. Tri-Tech combined with J&Y?s superior technology will result in synergies that will enhance Tri-Tech?s overall competitive advantage The operating assets belong to J&Y International, Inc., a designer and manufacturer of water

							purification and wastewater treatment systems.
Clean TeQ Holdings Limited	Developing, commercializing and selling air purification, metal recovery and water purification technologies	Investment	Aqua Guardian Group	Continuous Ionic Filtration, Desalination, Membrane Pre-Treatment, Zero Liquid Dischange, UV Disinfection, Clean Air Strippers	$0.5 million	Australia	Clean TeQ Holdings Limited announced that Aqua Guardian Group Limited has an interest of 32,624,708 ordinary shares, which represents 22.7% of voting power in the Company.
Liqtech USA, Inc. (LUSA)	LUSA is a US-based cleantech company engaged in developing and providing of technologies for gas and liquid purification using ceramic silicon carbide filters, particularly, for the control of soot exhaust particles from diesel engines and for water filtration	Private Placement	Blue Moose Media	Silicon Carbide Ceramic Membranes Filtration (MF and UF membranes)	$6.3 million	United States	Liqtech USA, Inc. is a cleantech company that developes and provides technologies for gas and liquid purification using ceramic silicon carbide filters, particularly, highly specialized filters for the control of soot exhaust particles from diesel engines and for water filtration.

Joint Ventures, Licensing and IPO

The following table shows the joint venture, licensing and IPO activity in detail for membrane separation.

Company	Technology focus	Technology	Deal type	Funder/Company	Funding Amount	Geography	Other Details
Tianjin MOTIMO Membrane Technology Co., Ltd	Tianjin MOTIMO Membrane Technology Co., Ltd. is a manufacture of membrane module and equipment. The company provides hollow fiber membrane module, technical guidance and the after-sale service.The company?s products include column hollow fiber, FP membrane module, SMF membrane module, and drinking water purification device	Membrane technology, Microfiltration, Ultrafiltration	IPO	NA	$77.19 million	China	NA
Eureka Forbes, Ltd.	Eureka Forbes, Ltd. is a manufacturer of water purification systems, vacuum cleaners, and air purifiers. The company also offers security solutions, including home security systems, intrusion alarm systems, access control systems, fire alarm systems, and surveillance systems. In addition, it offers industrial solutions, such as industrial water purifiers, commercial and industrial vacuum cleaners, hard floor cleaning and maintenance machines, high	E-boiling, UV filtration, Reverse Osmosis, Ultra Filtration, SMP technologies, Chemical purification based on iodinated resin	Partnership & licensing	Water Security Corporation, Inc	NA	India	Eureka Forbes, Ltd. has entered into a partnership and licensing agreement with Water Security Corporation, Inc. (WSC), to launch a low-cost water purification system called Aquasure Galaxy, based on WSC?s technology originally developed to be used by NASA in space, which is certified by the US EPA (Environment Protection Agency). Water Security Corporation, Inc. (WAC) is a provider of water purifying technology that kills disease causing

	pressure cleaners, and cleaning and hygiene products						germs and provides drinking water at the point-of-use including homes, medical centers, schools, offices, and rural villages. The company licenses its purification technology to companies that manufacture and market consumer water purification products, portable water purifiers, and other point-of-use and point-of-entry water purification products. Additionally, WSC manufactures and sells rural village water purification systems through regional distributors.
Clean TeQ Holdings Limited	developing, commercializing and selling air purification, metal recovery and water purification technologies	Continuous ion exchange, Membrane processes	Partnership (Joint Venture)	Nippon Gas Co., Ltd	Nippon Gas will invest AUD4 million ($4.29 million) in the joint venture to hold 50% stake and Clean TeQ will provide an exclusive license to use its proprietary CIF(TM) technology in this industry in Australia	Australia	Clean TeQ Holdings Limited has formed a joint venture with Nippon Gas Co., Ltd., to provide water desalination facilities and services in the Australian coal seam gas industry. The joint venture is named as Associated Water Pty., Ltd.
ItN Nanovation AG	nanotechnology company that manufactures and markets ceramic products	Nanotechnology	Partnership (Joint Venture)	E.A. Juffali & Brothers	NA	Saudi Arabia	The products of the joint venture will be used in the area of prefiltration for reverse osmosis for the treatment of drinking water. The joint venture will improve market access for ItN Nanovation, thereby allowing it to better address a region that is one of the core markets for the treatment of drinking water using ceramic flat membranes. The joint venture also marks another milestone for ItN Nanovation by allowing the mass production of CFM systems as well as representing a further proof of concept of the performance and industrial applications of ItN technology in cooperation with external international partners.

Irradiation

This section details out the financial activities in the last 2 years in the irradiation segment.

Venture Capital Investments

The following table shows the venture capital investment activity in detail for irradiation.

Investor Company	Description	Invested company	Invested technology	Invested Amount	Sources
Dow Chemical Company	With annual sales of $54 billion and 46,000 employees worldwide, Dow is a diversified chemical company that combines the power of science and technology with the " Human Element " to constantly improve what is essential to human progress. The Company delivers a broad range of products and services to customers in around 160 countries, connecting chemistry and innovation with the principles of sustainability to help provide everything from fresh water, food and pharmaceuticals to paints, packaging and personal care products.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
Sail Venture Partners (SAIL)	SAIL Venture Partners, L.P. is a national venture capital firm with offices in Southern California and Washington, D.C., investing in early-stage companies primarily in the Energy/Cleantech sector. The SAIL partners invest through two primary funds, which focus on clean technologies in the areas of alternative energy, water, agriculture and materials.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
International Finance Corporation (IFC)	International Finance Corporation is a private equity and venture capital arm of World Bank specializing in both direct and fund investments. It seeks to invest in early stage companies.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$15 million	Waterhealth

Private Equity Funding

The following table shows the private equity funding in detail for irradiation.

Company	Technology focus	Deal type	Funder/Company	Technology invested in	Funding Amount	Geography	Other Details
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	Undisclosed Investors	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$22.5 million	United States	Received in the 1st Quarter of 2012
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	Dow Venture Capital (Dow) and Sail Venture Partners (SAIL)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	more than $10 million	United States	WHI has more than 600 installations of its water purification and disinfection systems in developing countries around the world. This additional funding further strengthens WHI and will allow for accelerated growth.
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology.	Funding	International Finance Corporation (IFC)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge	$15 million	United States	The facility is in the form of long term loans to help more than 600 communities in India fund the purchase of WaterHealth Centres

	Its products include household systems, community water systems, and emergency relief units.			filter), reverse osmosis			over the next 18 months, with the capacity to serve more than three million people.

Mergers and Acquisitions

The following table shows the mergers and acquisitions in detail for irradiation.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Grundfos Holding A/S	Grundfos Holding A/S is a manufacturer of pumps. The company?s products include circulator, submersible, and centrifugal pumps. It serves agriculture, automotive, biofuel, food, agricultural water distribution, agricultural water treatment, beverage, commercial buildings, and HVAC OEM sectors	Acquisition	Enaqua	Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis (RO), UV disinfection	Undisclosed	United States	The acquisition will allow Grundfos to obtain new technology and competence as a strong supplement to its existing business and enable to deliver new solutions for water treatment with strengthened focus on sustainability. Enaqua is a provider of an environmentally friendly advanced purification solutions. The company has developed ultraviolet disinfection equipment based on Activated Fluoropolymer Technology (AFP?). It manufactures non-contact disinfection systems and membrane systems.
Undisclosed	An investor group, has acquired an equity stake in excess of 5% in WaterHealth International, Inc., a provider of water treatment solutions based on water purification and disinfection technology. Both the entities are based in the US	Acquisition	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	5% stake	United States	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units
Nubian Water Systems Pty., Ltd.	Nubian Water is a developer and distributor of sustainable water solutions	Acquisition	UV-Guard Australia Pty., Ltd	Disinfection solutions including Ultraviolet, Ozone and Advanced Oxidation processes	$1.36 million	Australia	Nubian Water Systems Pty., Ltd. has signed an agreement to acquire UV-Guard Australia Pty., Ltd., a designer and distributor of ultra violet disinfection products, from Clean TeQ Holdings Limited
Clean TeQ Holdings Limited	Developing, commercializing and selling air purification, metal recovery and water purification technologies	Investment	Aqua Guardian Group	Continuous Ionic Filtration, Desalination, Membrane Pre-Treatment, Zero Liquid Dischange, UV Disinfection, Clean Air Strippers	$0.5 million	Australia	Clean TeQ Holdings Limited announced that Aqua Guardian Group Limited has an interest of 32,624,708 ordinary shares, which represents 22.7% of voting power in the Company.

Joint Ventures, Licensing and IPO

The following table shows the joint venture, licensing and IPO activity in detail for irradiation.

Company	Technology focus	Technology	Deal type	Funder/Company	Funding Amount	Geography	Other Details
Eureka Forbes, Ltd.	Eureka Forbes, Ltd. is a manufacturer of water purification systems, vacuum cleaners, and air purifiers. The company also offers security solutions, including home security systems, intrusion alarm systems, access control systems, fire alarm systems, and surveillance systems. In addition, it offers industrial solutions, such as industrial water purifiers, commercial and industrial vacuum cleaners, hard floor cleaning and maintenance machines, high pressure cleaners, and cleaning and hygiene products	E-boiling, UV filtration, Reverse Osmosis, Ultra Filtration, SMP technologies, Chemical purification based on iodinated resin	Partnership & licensing	Water Security Corporation, Inc	NA	India	Eureka Forbes, Ltd. has entered into a partnership and licensing agreement with Water Security Corporation, Inc. (WSC), to launch a low-cost water purification system called Aquasure Galaxy, based on WSC?s technology originally developed to be used by NASA in space, which is certified by the US EPA (Environment Protection Agency). Water Security Corporation, Inc. (WAC) is a provider of water purifying technology that kills disease causing germs and provides drinking water at the point-of-use including homes, medical centers, schools, offices, and rural villages. The company licenses its purification technology to companies that manufacture and market consumer water purification products, portable water purifiers, and other point-of-use and point-of-entry water purification products. Additionally, WSC manufactures and sells rural village water purification systems through regional distributors.

Ion Exchange

This section details out the financial activities in the last 2 years in the ion exchange segment.

Venture Capital Investments

The following table shows the venture capital investment activity in detail for ion exchange.

Investor Company	Description	Invested company	Invested technology	Invested Amount	Sources
SAS Investors	SAS Investors targets companies that provide solutions based on technology emerging out of tech transfer centers, universities, and/or corporate labs in which a subject matter expert has developed unique IP that is particularly relevant to industry pain points	HydroGlobe. Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	$1.1 million	Poodyglitz

Private Equity Funding

The following table shows the private equity funding in detail for ion exchange.

Company	Technology focus	Deal type	Funder/Company	Technology invested in	Funding Amount	Geography	Other Details
HydroGlobe. Inc	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative	Venture Financing	SAS Investors, New Product Development Consortium, Stevens Institute of Technology	Arsenic & lead removal technology, Ion exchange, Crossflow membranes,	$1.1 million	United States	The funds raised would facilitate Hydroglobe to build a market presence for MetSorb, its new filter media for

	and affordable water-purification technology to municipalities and consumers			liquid process filters			Arsenic removal, and to hire the work force needed to sell and implement its equipment solutions.

Mergers and Acquisitions

The following table shows the mergers and acquisitions in detail for ion exchange.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Graver Technologies	Designs, develops, and manufactures products that facilitate and enhance separation, purification, and process filtration	Acquisition	HydroGlobe, Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	Undisclosed	United States	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative and affordable water-purification technology to municipalities and consumers
Seprotech Systems Incorporated	Seprotech Systems is an environmental technology company engaged in the manufacture and sale of water and wastewater treatment systems. The company offers packaged systems including industrial membrane systems, mobile response package plants, purification equipment, rotating biological contactors, wastewater treatment and water treatment equipment. In addition, it offers industrial solutions such as microfiltration, nano filtration, reverse osmosis, ultra filtration; and water and wastewater treatment solutions. The company primarily operates in Canada, where it is headquartered in Ottawa.	Acquisition	WESA Group	Aerobic and anaerobic biological, Physical / chemical treatment, Dissolved air flotation, Media Filtration, Activate carbon adsorption, Enhanced Oxidation, Dewatering and sludge handling, Ion exchange, Reverse osmosis, Ultrafiltration and microfiltration, Evaporation	$2.03 million	Canada	With this acquisition, Seprotech will become a major provider of earth sciences, water resources and environmental engineering services, and wastewater/water treatment systems. The combined entities will be able to provide their clients with a much broader spectrum of professional services and complete systems to solve their problems and WESA will have a platform for much more rapid growth.
Tri-Tech Holding, Inc.?s subsidiaries Tri-Tech International Investment, Inc. and Tri-Tech Infrastructure, LLC	Tri-Tech Holding is a China-based designer of customized sewage treatment and odor control systems	Acquisition	J&Y International, Inc	Evaporators, reverse osmosis, filtration, ion exchange, biological, physical and chemical methods	$1.5 million in cash and Tri-Tech stock	United States	With this acquisition, Tri-Tech will have the technology to expand into the markets for seawater desalination, water reuse, and zero liquid discharge (ZLD), driven by increased scarcity of water resources. Tri-Tech combined with J&Y?s superior technology will result in synergies that will enhance Tri-Tech?s overall

							competitive advantage The operating assets belong to J&Y International, Inc., a designer and manufacturer of water purification and wastewater treatment systems.
Clean TeQ Holdings Limited	Developing, commercializing and selling air purification, metal recovery and water purification technologies	Investment	Aqua Guardian Group	Continuous Ionic Filtration, Desalination, Membrane Pre-Treatment, Zero Liquid Dischange, UV Disinfection, Clean Air Strippers	$0.5 million	Australia	Clean TeQ Holdings Limited announced that Aqua Guardian Group Limited has an interest of 32,624,708 ordinary shares, which represents 22.7% of voting power in the Company.

Joint Ventures, Licensing and IPO

The following table shows the joint venture, licensing and IPO activity in detail for ion exchange.

Company	Technology focus	Technology	Deal type	Funder/Company	Funding Amount	Geography	Other Details
Clean TeQ Holdings Limited	developing, commercializing and selling air purification, metal recovery and water purification technologies	Continuous ion exchange, Membrane processes	Partnership (Joint Venture)	Nippon Gas Co., Ltd	Nippon Gas will invest AUD4 million ($4.29 million) in the joint venture to hold 50% stake and Clean TeQ will provide an exclusive license to use its proprietary CIF(TM) technology in this industry in Australia	Australia	Clean TeQ Holdings Limited has formed a joint venture with Nippon Gas Co., Ltd., to provide water desalination facilities and services in the Australian coal seam gas industry. The joint venture is named as Associated Water Pty., Ltd.
Global Ecology Corporation	Global Ecology is a US-based company engaged in the development, production and marketing of advanced technologies that focuses on water purification systems, restoration of bodies of water and the decontamination of waste to create high grade soil additives	Ion exchange	Partnership (Joint Venture)	Esoft Informatics, Pvt., Ltd	NA	India	Esoft Informatics Private Limited is a software company that provides business intelligence and information technology solutions. Its technology services include enterprise-wide solutions and implementation, database management services- back office, internet andintranet, BPO and KPO, e-commerce solutions, software development, application development, and systems integration

Distillation or Evaporation

This section details out the financial activities in the last 2 years in the distillation or evaporation segment.

Venture Capital Investments

The following table shows the venture capital investment activity in detail for distillation or evaporation.

Investor Company	Description	Invested company	Invested technology	Invested Amount	Sources
Consol Energy	CONSOL Energy Inc. produces coal and natural gas for energy and raw material markets. The company is involved in the mining, preparation, and marketing steam coal primarily to electric power generation industry; and metallurgical coal to steel and coke producers.	Epiphany Solar Water Systems, LLC	Distilling water with concentrated solar energy	$0.5 million	Shalestuff

Private Equity Funding

The following table shows the private equity funding in detail for distillation or evaporation.

Company	Technology focus	Deal type	Funder/Company	Technology invested in	Funding Amount	Geography	Other Details
Epiphany Solar Water Systems, LLC	specializing in concentrated solar energy technologies	Private Equity	Consol Energy	Distilling water with concentrated solar energy	$0.5 million	United States	Epiphany Solar Water Systems, LLC is a product development company specializing in concentrated solar energy technologies. The company manufactures solar powered water desalination and purification system which uses concentrated solar energy rather than fossil fuels to purify water from nearly any source

Mergers and Acquisitions

The following table shows the mergers and acquisitions in detail for distillation or evaporation.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Seprotech Systems Incorporated	Seprotech Systems is an environmental technology company engaged in the manufacture and sale of water and wastewater treatment systems. The company offers packaged systems including industrial membrane systems, mobile response package plants, purification equipment, rotating biological contactors, wastewater treatment and water treatment equipment. In addition, it offers industrial solutions such as microfiltration, nano filtration, reverse osmosis, ultra filtration; and water and wastewater treatment solutions. The company primarily operates in Canada, where it is headquartered in Ottawa.	Acquisition	WESA Group	Aerobic and anaerobic biological, Physical / chemical treatment, Dissolved air flotation, Media Filtration, Activate carbon adsorption, Enhanced Oxidation, Dewatering and sludge handling, Ion exchange, Reverse osmosis, Ultrafiltration and microfiltration, Evaporation	$2.03 million	Canada	With this acquisition, Seprotech will become a major provider of earth sciences, water resources and environmental engineering services, and wastewater/water treatment systems. The combined entities will be able to provide their clients with a much broader spectrum of professional services and complete systems to solve their problems and WESA will have a platform for much more rapid growth.
Tri-Tech Holding, Inc.?s subsidiaries Tri-Tech International Investment, Inc. and Tri-Tech Infrastructure,	Tri-Tech Holding is a China-based designer of customized sewage treatment and odor control systems	Acquisition	J&Y International, Inc	Evaporators, reverse osmosis, filtration, ion exchange, biological, physical and chemical methods	$1.5 million in cash and Tri-Tech stock	United States	With this acquisition, Tri-Tech will have the technology to expand into the markets for seawater desalination, water

LLC							reuse, and zero liquid discharge (ZLD), driven by increased scarcity of water resources. Tri-Tech combined with J&Y?s superior technology will result in synergies that will enhance Tri-Tech?s overall competitive advantage The operating assets belong to J&Y International, Inc., a designer and manufacturer of water purification and wastewater treatment systems.

Filtration by Metal

This section details out the financial activities in the last 2 years in the filtration by metal segment.

Venture Capital Investments

The following table shows the venture capital investment activity in detail for filtration by metal.

Investor Company	Description	Invested company	Invested technology	Invested Amount	Sources
Dow Chemical Company	With annual sales of $54 billion and 46,000 employees worldwide, Dow is a diversified chemical company that combines the power of science and technology with the " Human Element " to constantly improve what is essential to human progress. The Company delivers a broad range of products and services to customers in around 160 countries, connecting chemistry and innovation with the principles of sustainability to help provide everything from fresh water, food and pharmaceuticals to paints, packaging and personal care products.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
Sail Venture Partners (SAIL)	SAIL Venture Partners, L.P. is a national venture capital firm with offices in Southern California and Washington, D.C., investing in early-stage companies primarily in the Energy/Cleantech sector. The SAIL partners invest through two primary funds, which focus on clean technologies in the areas of alternative energy, water, agriculture and materials.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$20 million (joint investment by Dow and SAIL)	Waterhealth
International Finance Corporation (IFC)	International Finance Corporation is a private equity and venture capital arm of World Bank specializing in both direct and fund investments. It seeks to invest in early stage companies.	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$15 million	Waterhealth
Lincoln Park Capital Fund, LLC	Lincoln Park Capital. Chicago-based Investment Group and Asset Management Firm focused on opportunistic investing in public and private companies, real estate & high alpha money management strategies.	PURE Bioscience	Silver dihydrogen citrate molecule	$10 million	Reuters
Doughty Hanson & Co	Doughty Hanson targets companies that develop sophisticated and proprietary technologies and focuses on three industry sectors: internet software, mobile communications and clean energy technology	Norit NV	Activated carbon	$1100 million	Mergermarketgroup

Euroland Investments B.V.	Euroland Investments B.V. and its subsidiaries develop, manufacture, sell and service its products for all kind of water transport applications.	Norit NV	Activated carbon	$1100 million	Mergermarketgroup
SAS Investors	SAS Investors targets companies that provide solutions based on technology emerging out of tech transfer centers, universities, and/or corporate labs in which a subject matter expert has developed unique IP that is particularly relevant to industry pain points	HydroGlobe. Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	$1.1 million	Poodyglitz

Private Equity Funding

The following table shows the private equity funding in detail for filtration by metal.

Company	Technology focus	Deal type	Funder/Company	Technology invested in	Funding Amount	Geography	Other Details
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	Undisclosed Investors	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$22.5 million	United States	Received in the 1st Quarter of 2012
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	Dow Venture Capital (Dow) and Sail Venture Partners (SAIL)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	more than $10 million	United States	WHI has more than 600 installations of its water purification and disinfection systems in developing countries around the world. This additional funding further strengthens WHI and will allow for accelerated growth.
WaterHealth International, Inc	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units.	Funding	International Finance Corporation (IFC)	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	$15 million	United States	The facility is in the form of long term loans to help more than 600 communities in India fund the purchase of WaterHealth Centres over the next 18 months, with the capacity to serve more than three million people.
PURE Bioscience	provider of pharmaceutical water purification products	Private Equity	Lincoln Park Capital Fund, LLC	Silver dihydrogen citrate molecule	$10 million	United States	Pure Bioscience provides pharmaceutical water purification products to the pharmacy market. The company develops and markets technology-based bioscience products that provide non-toxic solutions. The company?s proprietary toxicity bioscience technologies include its silver dihydrogen citrate-based antimicrobials and boric acid-based pesticides. Pure Bioscience develops pesticide technology, Triglycylboride that provides results without human toxicity and is an

							alternative to traditional poisons.
Norit NV	manufacturer and supplier of clean technologies and components for purification and filtration systems, to Cabot Corporation, a US-based specialty chemicals and performance materials company	Private Equity (Exit)	Doughty Hanson & Co V and Euroland Investments B.V. (PE Fund)	Activated carbon	$1100 million	Netherlands	Cabot Corporation bought Norit NV from Doughty Hanson & Co V and Euroland Investments B.V.
HydroGlobe. Inc	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative and affordable water-purification technology to municipalities and consumers	Venture Financing	SAS Investors, New Product Development Consortium, Stevens Institute of Technology	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	$1.1 million	United States	The funds raised would facilitate Hydroglobe to build a market presence for MetSorb, its new filter media for Arsenic removal, and to hire the work force needed to sell and implement its equipment solutions.

Mergers and Acquisitions

The following table shows the mergers and acquisitions in detail for filtration by metal.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Graver Technologies	Designs, develops, and manufactures products that facilitate and enhance separation, purification, and process filtration	Acquisition	HydroGlobe, Inc	Arsenic & lead removal technology, Ion exchange, Crossflow membranes, liquid process filters	Undisclosed	United States	HydroGlobe manufactures products that remove heavy metals including arsenic from water. It is a supplier of innovative and affordable water-purification technology to municipalities and consumers
Undisclosed	An investor group, has acquired an equity stake in excess of 5% in WaterHealth International, Inc., a provider of water treatment solutions based on water purification and disinfection technology. Both the entities are based in the US	Acquisition	WaterHealth International, Inc	UV light disinfection, multi-stage filtration (multimedia filter, advanced carbon filter & cartridge filter), reverse osmosis	5% stake	United States	WaterHealth International, Inc. is a provider of water treatment solutions based on water purification and disinfection technology. Its products include household systems, community water systems, and emergency relief units
Pentair, Inc	Diversified industrial manufacturing company	Acquisition	Clean Process Technologies (CPT) division on Norit Holdings B V	Activated carbon, Membrane Filtration,	$716.4 million	Netherlands	CPT is a provider of membrane solutions and clean process technologies for water and beverage filtration and separation segments CPT provides components, systems, and services that are expected to broaden and deepen Pentair?s capabilities in desalination, water reuse and high efficiency industrial applications and enable Pentair to provide more integrated solutions to its customers.

							The acquisition is also expected to strengthen Pentair in the food and beverage sector and in fast growth regions, including China, Latin America and the Middle East

Joint Ventures, Licensing and IPO

The following table shows the joint venture, licensing and IPO activity in detail for filtration by metal.

Company	Technology focus	Technology	Deal type	Funder/Company	Funding Amount	Geography	Other Details
FSI Energy Services, Inc	FSI Energy Services, Inc (Formerly known as Baden Technologies Inc.) manufactures, markets and installs filtration and filtration-related products. The company?s product line include filter vessels and filter media, salt brine blending plants, chemical blending plants, polymer blending plants, water injection packages, carbon absorbing vessels, mole drill cuttings cleaning systems, and aquashield water removal filters.	Electrocoagulation, carbon absorbing vessels	Partnership (Joint Venture)	Powell Water (Canada), Inc.	NA	Canada	FSI-Powell Water, Inc. is a joint venture company between FSI Energy Services, Inc. and Powell Water (Canada), Inc. The company provides comprehensive design, manufacturing, sales and service for state-of-the-art produced-water treatment FSI-Powell will combine FSI?s filtration and purification expertise with Powell Water?s technologies that will enable the JV to provide SAGD clients with efficient and cost- effective purification of their produced water.
Latitude Solutions, Inc	Latitude Solutions, Inc. is a holding company. The company, through its subsidiaries, offers products, processes and solutions for contaminated water applications; wireless telemetry/live video streaming security products to mobile assets and people; and marketing capabilities for both government and commercial sectors.	Electro Precipitation, Coalescing Oil & Polishing	Partnership (Licensing Agreement)	Separatech Canada, Inc.	NA	Canada	Separatech Canada, Inc. designs, manufactures, and distributes the COP-System, a proprietary brand of oily water separator used in oil and gas, groundwater remediation, industrial wastewater, shipping bilge water and oil spills industries

Filtration by Microbes

This section details out the financial activities in the last 2 years in the filtration by microbes segment.

Mergers and Acquisitions

The following table shows the venture capital investment activity in detail for filtration by microbes.

Acquirer	Technology focus of acquirer	Deal type	Acquired Company	Technology invested in	Funding Amount	Geography	Other Details
Ozone Water Systems, Inc.	distributor and installer of ozone water	Acquisition	Purfresh, Inc	Disinfection using Ozone generator	Undisclosed	United States	The acquisition will enable OWS to offer

	purification systems						both equipment and application support for a solid ozone equipment line. The divestment will allow Purfresh to focus more of its resources on the food industry. Purfresh?s water treatment systems deliver purification and disinfection for use in industrial, high-purity water applications, including beverage bottling, pharmaceutical, and personal care products.
Nubian Water Systems Pty., Ltd.	Nubian Water is a developer and distributor of sustainable water solutions	Acquisition	UV-Guard Australia Pty., Ltd	Disinfection solutions including Ultraviolet, Ozone and Advanced Oxidation processes	$1.36 million	Australia	Nubian Water Systems Pty., Ltd. has signed an agreement to acquire UV-Guard Australia Pty., Ltd., a designer and distributor of ultra violet disinfection products, from Clean TeQ Holdings Limited
Siemens Industry Automation Division	Siemens Industry Automation Division is a provider of a complete and integrated line of products, systems, and solutions for production and process automation for manufacturing industries, process and basics industries, and research, development, and training centers	Acquisition	Cambridge Water Technology, Inc	CoMag, a solid and precipitated particulate removal process based on the process of coagulation, flocculation, and clarification that produces effluent equivalent to ultra-filtration; and BioMag, a retrofit application that enhances the performance of biological treatment systems, increases capacity, catalyzes biological productivity, and produces effluent for activated sludge plants needing treatment capacity or enhanced nutrient removal capability	Undisclosed	United States	The acquisition will strengthen the Siemens product portfolio with technologies for advanced water and wastewater treatment Cambridge Water Technology, Inc. is engaged in providing municipal and industrial wastewater treatment facilities.
Seprotech Systems Incorporated	Seprotech Systems is an environmental technology company engaged in the manufacture and sale of water and wastewater treatment systems. The company offers packaged systems including industrial membrane systems, mobile response package plants, purification equipment, rotating biological contactors, wastewater treatment and water treatment equipment. In addition, it offers industrial solutions such as microfiltration, nano filtration, reverse osmosis, ultra	Acquisition	WESA Group	Aerobic and anaerobic biological, Physical / chemical treatment, Dissolved air flotation, Media Filtration, Activate carbon adsorption, Enhanced Oxidation, Dewatering and sludge handling, Ion exchange, Reverse osmosis, Ultrafiltration and microfiltration, Evaporation	$2.03 million	Canada	With this acquisition, Seprotech will become a major provider of earth sciences, water resources and environmental engineering services, and wastewater/water treatment systems. The combined entities will be able to provide their clients with a much broader spectrum of professional services and complete systems to solve their problems and WESA will have a platform for much more rapid growth.

	filtration; and water and wastewater treatment solutions. The company primarily operates in Canada, where it is headquartered in Ottawa.						
Tri-Tech Holding, Inc.?s subsidiaries Tri-Tech International Investment, Inc. and Tri-Tech Infrastructure, LLC	Tri-Tech Holding is a China-based designer of customized sewage treatment and odor control systems	Acquisition	J&Y International, Inc	Evaporators, reverse osmosis, filtration, ion exchange, biological, physical and chemical methods	$1.5 million in cash and Tri-Tech stock	United States	With this acquisition, Tri-Tech will have the technology to expand into the markets for seawater desalination, water reuse, and zero liquid discharge (ZLD), driven by increased scarcity of water resources. Tri-Tech combined with J&Y?s superior technology will result in synergies that will enhance Tri-Tech?s overall competitive advantage The operating assets belong to J&Y International, Inc., a designer and manufacturer of water purification and wastewater treatment systems.

Joint Ventures, Licensing and IPO

The following table shows the joint venture, licensing and IPO activity in detail for filtration by microbes.

Company	Technology focus	Technology	Deal type	Funder/Company	Funding Amount	Geography	Other Details
Ecosphere Technologies, Inc.	Ecosphere Energy Services, LLC is a provider of proprietary water purification and management services to the energy industry. The company manufactures water purification and management units, using Ozonix(TM) technology.	Advanced Oxidation Technology which uses Ozone, Hydrodynamic Cavitation, Acoustic Cavitation, and Electro-Oxidation	Partnership (Licensing Agreement)	Hydrozonix, LLC	$44 million	United States	Ecosphere Technologies, Inc. and its majority owned subsidiary Ecosphere Energy Services, LLC, have signed an exclusive technology licensing agreement with Hydrozonix, LLC to deploy its patented Ecosphere Ozonix technology in the US oil and gas exploration and production industry Ecosphere Technologies, Inc. is a provider of water filtration expertise, water recycling technologies, and services to energy companies. The company develops clean technological applications and solutions to the industrial waste market.

Nanotechnology in Water Purification

This section lays out the landscape of nanofiltration technology segment of water purification in detail covering the market information, major players, company profiles of start-up companies and university research going on in the nanofiltration for water purification.

Market Size

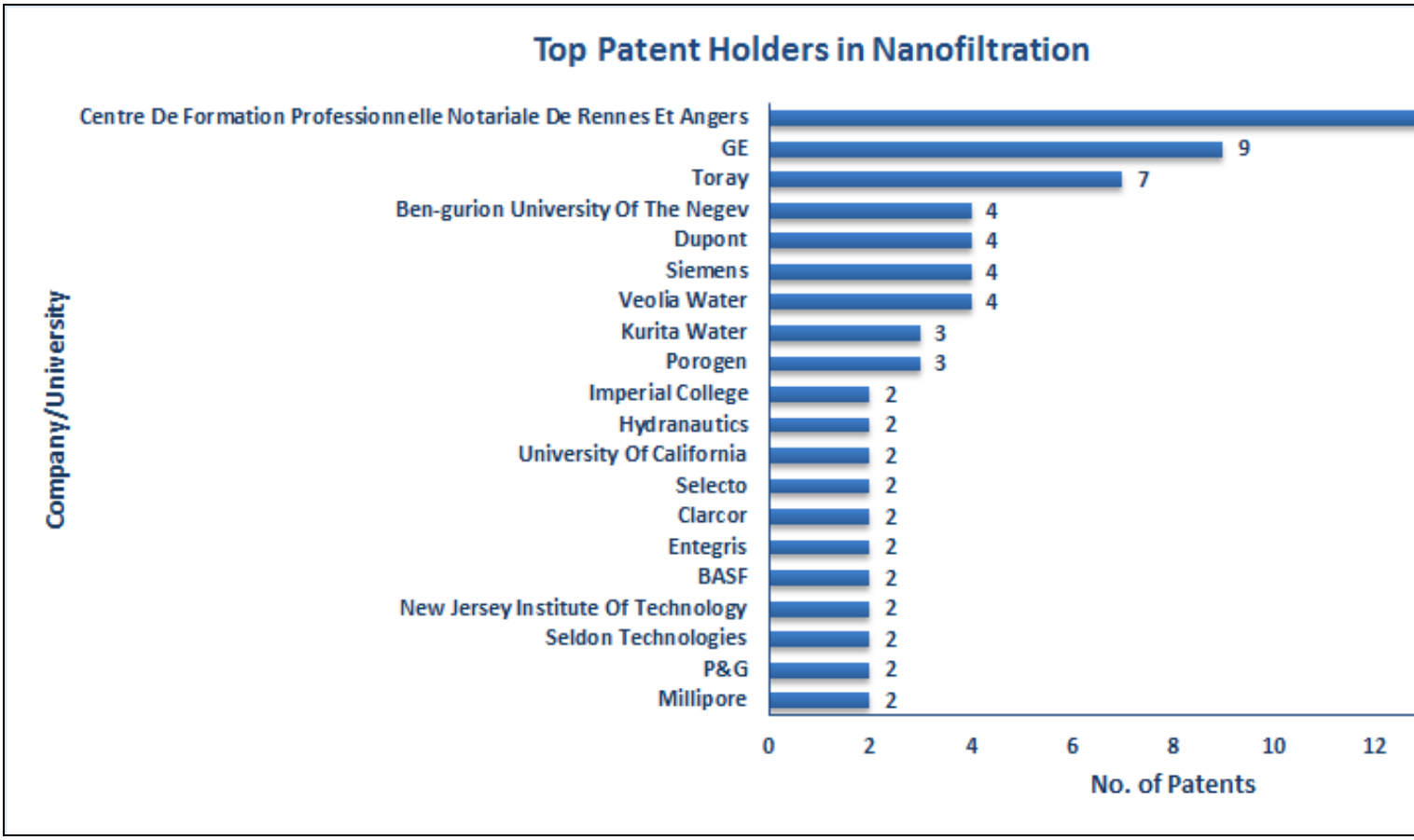
- The global market for nanotechnology products used in water treatment was worth an estimated $1.4 billion in 2010
- The market will grow at a compound annual growth rate (CAGR) of 9.7% during the next 5 years to reach a value of $2.2 billion in 2015.

Source: BCC Research

Major Companies

Top Patent Holders in Nanofiltration for Water Purification

The following chart shows the major companies in the Nanofiltration technology by the number of patents they hold in this segment.



Other Companies

The following table contains a list of other companies in the field of nanofiltration in water purification:

3m Corp	Halox Technologies	Osmoflo Pty Ltd	Surrey Aqua Technology Limited
Akzo Nobel Nv	Hollingsworth & Vose Gmbh	Paragon Water Systems	Tata Chemicals Ltd
Aquasource	Honeywell International Inc	Prominent Dosiertechnik Gmbh	Technion Research And Development Foundation Ltd.
Cognis Deutschland Gmbh & Co Kg	Inframat Corp	Saati	The Dow Chemical Company
Creative Micro Tech	International Business Machines Corp	Saline Water Conversion Corporation	The Purolite Company
Donaldson Co Inc	Itn Nanovation Ag	Samsung	Veolia Environnement

Dual Vortex Microfiltration	Metso Oy	Sgl Group	Veolia Group
Ecolochem	Millipore Corporation	Solvay Sa	Zenon Environmental Inc
Fleetguard	Mitsubishi Corporation	Stichting Wetsus Centre Of Excellence For Sustainable Water Technology	
Hager Elsaesser	Norit Proces Technologie Holding Bv	Sumitomo Group	

Startups

This section profiles some of the start-up companies in the nanofiltration segment of water purification.

List of Startups

The following startups are present in the field of nanofiltration for water purification:

- NanoH20
- Puralytics
- Porogen Corp
- Seldon Technologies Inc.
- Entegris Inc
- EconoPure Water Systems
- Aquaporin Aps
- Proacqua Group S.r.l.
- Kinetico Incorporated
- KX Technologies
- Surrey Aquatechnology Ltd
- Vestergaard Frandsen Sa
- Cnanoz Inc
- Yakima Filters
- Liquid Asset Development Llc
- X Flow B.v.

Company Profiles

NanoH2O

NanoH2O, Inc. designs, develops, manufactures and markets reverse osmosis (RO) mem−branes that lower the cost of desalination. Based on breakthrough nanostructured materials and industry-proven polymer technology, licensed original TFN technology from University of California, Los Angeles, NanoH2O?s QuantumFlux membranes dramatically improve desalination energy efficiency and productivity. QuantumFlux seawater reverse osmosis (SWRO) membranes, Standard 61 certified by NSF International for the production of drinking water, deliver the highest flux and the highest salt rejection of any SWRO membrane on the market. QuantumFlux membranes are available in standard 8-inch (20 cm) diameter elements that fit easily into new and existing desalination plants, purifying water from a broad range of sources with improved productivity and water quality. NanoH2O is the 2011 Aquatech Innovation Award Winner in the Water Supply category. Quantum Flux membranes are installed in over 50 commercial sites across six continents, representing over 80,000 m3 per day (21 million gallons per day) in cumulative capacity.

The startup has developed its technology based on research from the University of California at Los Angeles. Its formula adds a nanomaterial to a conventional polymer membrane for desalination in order to alter its structure and make it easier for the water to pass through while it blocks out salt and other minerals. The water is potable afterward, but utilities sometimes add back some of the minerals that are filtered out before delivering the water to homes and businesses.

Company Snapshot

Company Name	NanoH2O
Founded	2005
Technology Description	Membrane Technology (QuantumFlux)
Key People	Jeff Green (Founder & CEO) Bob Burk (Founder & CSO)
Revenue	$4.90 million
Employees	26
Address	570 Westwood Plaza Suite 6532 Los Angeles, CA, 90095-7277 USA
Products	Quantum Flux membranes

Corporate History

Date	Activity
2005	Company founded by Jeff Green (Chief Executive Officer) and Robert Burk (Chief Scientific Officer)
2006	Filed first set of patents on nanocomposite membrane technology
2008	Achieved twice the flux of traditional polyamide membranes with >99.7% salt rejection on bench scale tests
2009	Successfully completed one year of long-term testing at U.S. Navy Desalination Testing Facility in Port Hueneme, California
2010	Commenced full-scale commercial manufacturing in El Segundo, California
2011	Introduced the highest flux SWRO membrane in the industry
2012	Introduced the highest rejection SWRO membrane on the market

Investment Landscape

Date	Investors	Funding Type	Amount
May, 2007	Khosla Ventures	Venture	$5.00 million
Dec, 2011	Khosla Ventures Oak Investment Partners	Venture	$30.00 million
Apr, 2012	BASF Venture Capital America Total Energy Ventures Keytone Ventures Khosla Ventures Oak Investment Partners PCG Clean Energy & Technology Fund Comerica Bank Lighthouse Capital Partners	Venture	$60.50 million

Source: CrunchBase, PrivCo

Puralytics

Founded in 2007, Puralytics has developed a cost efficient water purification system for distributed use. The company?s products, enabled by advances in semiconductors, optics, and nanotechnology, use natural or LED light to induce photochemical reactions to purify a given volume of water.

Puralytics? purification technology uses only light energy to activate a photocatalyst nano coating. Water is purified by five simultaneous photochemical reactions, breaking down organic compounds, reducing and removing heavy metals and sterilizing microorganisms. There are no chemical additives and 100% of the water is purified.

Puralytics currently markets two product lines; the Shield and the SolarBag, both based upon Puralytics patent-pending technology. Electrically powered, the Shield is a LED based purification stand-alone system or system component. This unit has an extremely small footprint at 28"x19"x8" and provides 500 gallons per day of purified water. The SolarBag is a direct sunlight activated photochemical water purification bag, manufactured and distributed by channel partners, which can purify 3 liters of water when placed in sunlight for 2 - 4 hours. The SolarBag has promising applications in remote military, emergency response, and emerging markets.

Hydration Technologies? humanitarian water division is helping Puralytics sell the SolarBag to nonprofits that will distribute it.

Company Snapshot

Company Name	Puralytics
Founded	2007
Technology Description	Light-activated Nanotechnology
Key People	Mark Owen (President & CEO) Ed Kolasinski (COO)
Revenue	$0.70 million
Employees	8
Address	15250 NW Greenbrier Pkwy Beaverton, OR 97006 USA
Products	SolarBag 3L, Shield

Corporate History

Date	Activity
2007	Mark Owen leaves Phoseon Technology and starts Puralytics
Apr, 2009	Puralytics gets chosen by The Artemis Project as a Top 50 Global Water Technology Company competition winner
2009	Puralytics pioneers a new photochemical process for water purification and gets a grant from National Science Foundation (NSF)
2010	Puralytics wins the grand prize of the 2010 Cleantech Open business competition
2011	Puralytics included in the 2011 Global Cleantech 100 list
2012	Puralytics gets invited to Global Cleantech 100 Summit & Gala

Investment Landscape

Date	Investors	Funding Type	Amount
Oct, 2009	National Science Foundation (NSF)	Grant	$148,796
Mar, 2010	Oregon Nanotechnologies and Microtechnologies Institute (ONAMI)	Grant	$0.25 million
2009-2011	Engmann Options LLC Steifel Foundation LLC 10 Angel Investors Management Team	Venture	$0.83 million
2012	Currently Seeking	Private + Venture	$3.00 million

Universities/Institutes

This section covers some of the university research in the nanofiltration segment of water purification.

IIT Madras

Graphene from Sugar and its Application in Water Purification In Collaboration with: VIT Madras

This paper describes a green method for the synthesis of graphenic material from cane sugar, a common disaccharide. A suitable methodology was introduced to immobilize this material on sand without the need of any binder, resulting in a composite, referred to as graphene sand composite (GSC). Raman spectroscopy confirmed that the material is indeed graphenic in nature, having G and D bands at 1597 and 1338 cm?1, respectively. It effectively removes contaminants from water. Here, we use rhodamine 6G (R6G) as a model dye and chloropyrifos (CP) as a model pesticide to demonstrate this application. The spectroscopic and microscopic analyses coupled with adsorption experiments revealed that physical adsorption plays a dominant role in the adsorption process. Isotherm data in batch experiments show an adsorption capacity of 55 mg/g for R6G and 48 mg/g for CP, which are superior to that of activated carbon. The adsorbent can be easily regenerated using a suitable eluent. This quick and cost-effective technique for the into a commercial water filter with appropriate engineering.

Source: ACS

Understanding the Degradation Pathway of the Pesticide, Chlorpyrifos by Noble Metal Nanoparticles

Application of nanoparticles (NPs) in environmental remediation such as water purification requires a detailed understanding of the mechanistic aspects of the interaction between the species involved. Here, an attempt was made to understand the chemistry of noble metal nanoparticle?pesticide interaction, as these nanosystems are being used extensively for water purification. Our model pesticide, chlorpyrifos (CP), belonging to the organophosphorothioate group, is shown to decompose to 3,5,6-trichloro-2-pyridinol (TCP) and diethyl thiophosphate at room temperature over Ag and Au NPs, in supported and unsupported forms. The degradation products were characterized by absorption spectroscopy and electrospray ionization mass spectrometry (ESI MS). These were further confirmed by ESI tandem mass spectrometry. The interaction of CP with NP surfaces was investigated using transmission electron microscopy, energy dispersive analysis of X-rays, Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS). XPS reveals no change in the oxidation state of silver after the degradation of CP. It is proposed that the degradation of CP proceeds through the formation of AgNP?S surface complex, which is confirmed by Raman spectroscopy. In this complex, the P?O bond cleaves to yield a stable aromatic species, TCP. The rate of degradation of CP increases with increase of temperature and pH. Complete degradation of 10 mL of 2 ppm CP solution is achieved in 3 h using 100 mg of supported Ag@citrate NPs on neutral alumina at room temperature at a loading of 0.5 wt %. The effect of alumina and monolayer protection of NPs on the degradation of CP is also investigated. The rate of degradation of CP by Ag NPs is greater than that of Au NPs. The results have implications to the application of noble metal NPs for drinking water purification, as pesticide contamination is prevalent in many parts of the world. Study shows that supported Ag and Au NPs may be employed in sustainable environmental remediation, as they can be used at room temperature in aqueous solutions without the use of additional stimulus such as UV light.

Source: ACS

Department of Environmental Geosciences, University of Vienna

Measuring and Modeling Adsorption of PAHs to Carbon Nanotubes Over a Six Order of Magnitude Wide Concentration Range

Understanding the interactions between organic contaminants and carbon nanomaterials is essential for evaluating the materials? potential environmental impact and their application as sorbent. Although a great deal of work has been published in the past years, data are still limited in terms of compounds, concentrations, and conditions investigated. We applied a passive sampling method employing polyoxymethylene (POM-SPE) to gain a

better understanding of the interactions between polycyclic aromatic hydrocarbons (PAHs) and multiwalled carbon nanotubes (CNTs) over a 6 orders of magnitude wide concentration range. In the low-concentration range (pg-ng L?1), sorption of phenanthrene and pyrene was linear on a nonlogarithmic scale. Here, sorption could thus be described using a single sorption coefficient. Isotherm fits over the entire concentration range showed that (i) monolayer sorption models described the data very well, and (ii) the CNTs sorption capacity was directly related to their surface area. Sorption coefficients for 13 PAHs (11 of which have not been reported to date) were also measured at environmentally relevant low concentrations. No competition seemed to occur in the low-concentration range and sorption affinity was directly related to the solubility of the subcooled liquid of the compounds.

Source: ACS, Medienportal

National Nanotechnology Center, NANOTEC, Thailand

"SOS water" mobile water purifier

Researchers at Thailand?s National Nanotechnology Center (NANOTEC) have build the first locally made prototype solar powered water purification unit "SOS water" which combined the use of antimicrobial nanocoating to ceramic filters. Compared to conventional ceramic filter, an antimicrobial nanocoating ceramic filter will increase an extra security by killing or incapacitating bacteria left in the water and preventing the growth of mold and algae in the body of the filter. The project was implemented as a result of the need to provide drinking water to communities affected by the 2011 mega flooding in Thailand.

The researchers adapted the antimicrobial nanocoating know-how for water filtration and assembled into in the production of mobile solar-operating system (SOS) water purification. The raw water goes through 6 filtration steps one of which is the antimicrobial nanocoating ceramic filtration unit. The quality of drinking water meets the 2010 guide standard of drinking water by Department of Health, Ministry of Public Health, Thailand. The SOS water system is capable of producing 200 liters of drinking water per hour and easily integrated into a pick-up, light truck, a trailer or a flat hull boat. The researchers have collaborated with the Thai Red Cross Society to do field testing of a prototype SOS water the result of which was outstanding. NANOTEC has donated the prototype SOS water to HRH Princess Maha Chakri Sirindhorn, Executive Vice President of the Thai Red Cross Society on June 28, 2012 for community relief effort.

Source: NANOTEC

LEITAT Technological Center, Spain

Ceramic and Polymeric Membranes for Water Purification of Heavy Metals and Hazardous Organic Compounds

To develop a new generation of nanostructured Low-Fouling and Self-Cleaning Membranes for Water Purification possessing several key properties such as:

- catalytic degradation of pharmaceuticals and organics
- removal of heavy metals
- scavenging of precious metals and rare earths

Source: Nano4water

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Germany

Fouling resistant ceramic honeycomb nanofilters for efficient water treatment

Improve the efficiency of high performance water purification by ceramic membranes:

- strongly increase membrane area of ceramic NF membranes
- apply and test anti fouling layers to reduce fouling tendency
- develop process schemes for treatment of different waters
- Life cycle assessment, cost analysis, techno-economical evaluation
- Active participation of industrial partners: RKV (membrane manufacturer), VMW (end-user) and CYCLUS (OEM, end-user)

Source: Nano4water

Division of Materials Science, Lulea University of Technology, Sweden

Nanoenabled membranes based on bio-materials for water purification

- Development of bio-based nano-enhanced membranes for water treatment, with special focus on fertilizers, pesticides, heavy metal ions and mictobial contaminants relevant in Europe
- Use biobased nanomaterials like cellulose nanofibers and cellulose or chitin nanocrystals isolated from industrial residues and side-streams
- Tailored interaction with contaminants and low/anti fouling by surface functionalization
- The membranes and filters, possible compostable after use (eg. with recovered fertilizers)
- Prototype of membrane modules and scale up plan

Source: Nano4water

Harvard University, School of Engineering and Applied Sciences

An Electrochemical Carbon Nanotube Filter for Water Treatment Applications

Carbon nanotubes (CNTs) have a number of unique physical chemical properties such as have high aspect ratios, high specific surface areas, mechanical strength, chemical stability, and are conducting or semiconducting. Thus, CNTs can be formed into mechanically-strong and electrically-conducting porous thin films or three-dimensional networks that have potential for many applications including water purification. Chad D. Vecitis of Harvard University designed and modified a filtration device to allow for in situ electrochemistry using a perforated stainless steel cathode and an electrochemically-active multi-walled carbon nanotube (MWNT) microfilter anode; 40 to 100 mm in height and pore diameter of 50 to 130 nm. The electrochemical carbon nanotube filter performance towards the removal and oxidation of aqueous dyes, anions, and microorganisms is evaluated.

Electrochemical filtration at 2 V resulted in >98% oxidation of influent dye and >6-log removal and/or inactivation of influent bacteria and virus. Environmental applications of the electrochemical CNT filter are discussed.

Source: Harvard University, Carnegie Mellon

Penn Engineering, University of Pennsylvania

High Speed Water Sterilization System for Developing Countries

HydraVita is a high-speed water sterilization system designed for use in developing countries. To our knowledge, this is the first sterilization system to implement a silver nanowire/carbon nanotube-coated cotton filter (AgNW/CNT filter). The device?s main capabilities are inactivating bacteria and reducing the turbidity levels of water. In order to accomplish these objectives, HydraVita incorporates two main components: a turbidity-mesh cartridge that eliminates organic impurities and a AgNW/CNT filter cartridge that kills bacteria. In order to power the filter, the system is equipped with two 12V rechargeable batteries and a solar panel. This allows HydraVita to be used in remote locations with no connection to the power grid. Furthermore, the system is designed for modularity so that it can be easily disassembled for cleaning and maintenance in the field. The input and output water reservoirs are outfitted with standard NPT valves that give operational flexibility to the user, as it can be directly connected to a hose, water tank, or piping system. HydraVita?s novelty stems from its high-speed functionality, low manufacturing cost, modularity, and ease of maintenance.

Source: FINAL POSTER.pdf Penn Engineering

Wright State University, United States

Metal Nanoparticles on Hierarchical Carbon Structures: New Architecture for Robust Water Purifiers

A new architecture for robustand powerful water purification media has been investigated. It consists of carbon nanotubes (CNT) attached to porous microcellular substrates. This is similar to several elegant and multifunctional designs seen in nature where dendrites and capillaries are attached to larger organs increasing their surface area. For this application, palladium and silver nanoparticles are attached to these surfaces for catalytic and anti-microbial activities. Palladium is a powerful catalyst for several reactions. In this study, the kinetics of carbon tetrachloride removal form water using Pd-activated material has been measured, and found to be very high. Silver nanoparticles are useful as antimicrobial agents and as plasmonic sensors. The effectiveness of these structures to remove E-coli from water has been tested, and the rates compared to currently available nano-silver materials. Both nano-particles were seen to be strongly attached to the nanotubes which were in turn strongly attached to the substrate. Durability tests indicate that failure occurs by delamination of graphite inside the substrate, rather than removal of individual CNT or nanoparticles from CNT. This observation bodes well for future use of this architecture in robust and efficient water purification devices.

Source: TechConnect

References

The following sources were referred to, while making this report.

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5. **Company Resources**
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   - Annual Reports
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