Search for a Spanish Partner for a Bilateral R&D Project

Organization	
Date of Request:	09/04/2025
Company name:	Egyptian Petroleum Research Institute (EPRI)
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SECTION 1: Entity launching the partner search *(Please give brief / to the point explanations. For more explanation on any point below, you may add a short paragraph as an annexure, with this document.)*	
Sector	EPRI provides analytical service, technical consultation, training programs, and technical inspection solutions. Its services include assessments, investigations, field activities, remediation, evaluation, petrology, scanning electron microscopy, gas chromatography, inspection, and training, as well as routine and special core, liquid chromatography and water, routine, and black oil analysis. The institution also offers material and mechanical services. It provides its services for exploration, production, analysis and evaluation, refining, petroleum applications, petrochemicals, and processes design and development departments of the oil sector.
Entity mission or core functions	EPRI is a leading research organization, over forty years of research and application researchers experts in compatable fields "Oil field chemicals, Petrochemicals, Polymers, Surfactants, Green & Biofuels, Refining, Processing and Development, Sedimentation, Petroleum exploration, Gheophysics, Catalysis and physical Separation, Pipeline transportation and storage of oil & gas , Reservoir engineering, Drilling Fluid, Enhanced Oil Recovery, Nanotechnology, Lubricant and Additives, Corrosion, Coating, Hazardous gas scavengers, Non- destructive tests". Develop studies & applications within the Petroleum sector, and to find solutions, to both long and short runs technical problems. Providing practical, pioneering solutions to take up the challenges facing society in terms of energy, water, and the industry, promoting the transition towards sustainable mobility and the emergence of a more diversified energy mix, we accomplish this mission through:

	• Our people: an extraordinary team of scientists, engineers, and support staff who work together across disciplines and, with our state-of-the-art facilities and capabilities, are the foundation of our organization. • Our partnerships: a rich history of trusted, dynamic working relationships with research entities throughout the world, and the clients we serve in industry and energy sector.
Date of establishment	EPRI has been established by the Presidential Decree no.541 for the year 1974, as one of the research institutes following the Ministry of Scientific Research, headed by his Excellency Minister of Higher Education and Scientific Research, with the aim of supplying the national petroleum industry with studies, scientific research work, consultations, analytical and technical services individually or together with other parties. In compliance with the Presidential Decree, the Chairman of the Board of Directors of EPRI is the Minister of Petroleum & Mineral Resources. Furthermore, a number of the senior personnel within the petroleum sector.
Ownership	EPRI is a public institute (governmental organization), under the umbrella of the Ministry of Scientific Research and Technology.
Total number of employees	1142
Number of employees in R&D	250
Key products sold or services provided	EPRI has 14 service units (www.epri.sci.eg/index.php/service-center) 1. Cathodic protection unit: Preserving the economic wealth of petroleum equipment, pipelines and reservoirs from erosion by exposing them to the surrounding environment. 2. Enhanced Oil Recovery by non-traditional ways: Establishment of a Semi-industrial compound for Enhanced Oil Recovery by non-traditional ways. 3. Quality control unit for coal analysis 4. Earth Sounding Unit 5. Core Analysis Lab 6. Fuel Research Unit (FRU) 7. Nanotechnology Center 8. Surfaces Protection center 9. Technical Support & technology center 10. Asphalt & polymers services center 11. Chemical Services and Development Center 12. Central Analytical labs 13. PVT Services Center 14. Tanks Services Center
Entity core technical	Supplying the petroleum and national industries with scientific studies, cutting edge research, consulting, analytical and

competences	technical services, and leadership in energy discoveries in various activities particularly in the oil and natural gas sectors and at the national and environmental levels. The fast development of EPRI researches is related to Egypt rapid economic and technical development. One of the most important objectives of our Institute, is to assist in solving the problems related to the petroleum industries. This can be achieved through expanding cutting edge research: to increase the rate of oil recovery from oil fields, separation of emulsified oil from formation water by advanced membrane technology, produce and develop field chemicals to facilitate crude oil production and transportation, gas sweetening or “H2S scavenging” and maximize the utilization of Egyptian natural gas, in the field of petrochemicals industries, and finally in the oil refining sectors. Localizing the advanced filtration membrane industry by producing and testing the polymers used in manufacturing these membranes, such as polyacrylonitrile, polysulfone, and chitosan. The institute researches aim at developing alternatives to petroleum products, using nanotechnology, especially in the production of biodiesel and mixing gasoline with alcohol to overcome lack in energy, serving the National industries.
Key R&D programs and activities	R & D Laboratories 1. Reverse Osmosis researches unit (RORU): including synthesis of polymers of advanced membranes, fabrication characterization of ultra and nanofiltration membranes, and provide of the consultants about membranes technology. 2. MWCNT & SWCNT lab. carbon nanotubes (CNTs) are nowadays one of the most extensively studied materials, because of their unique and advanced chemical, physical, magnetic and mechanical properties. 3. Planetary ball mill lab: offers a high degree of operating convenience, safety and versatility through using the high energy input. 4. Electrospinning lab: synthesizes fibers of high specific surface area, small diameters (20-1000 nm) and large porosity that can be used in different applications, such as filtration, catalysis, sensors, Bio-pharmaceutical, and energy applications.
Examples of accomplishments	Examples of accomplishments Protocols & Cooperation Internal Agreements • The Egyptian Petrochemicals Holding Company (Echem) • The Universities; Al-Mansoura, Ain Shams, Suez Canal & Cairo University • Science & Technology Center of Excellence (Ministry of Military Production) • The General Authority of Petroleum in The Following Studies & Projects: - Innovative& Complementary Ways of Enhanced Oil Recovery

	with Production Companies - Bitumen Modification with Refinery Companies - Alkanolamines Production in Coop-eration with Petrochemicals Companies. • The Egyptian Petrochemicals Holding Company (Echem) for Technical Cooperation • The Engineering for the Petroleum and Process Industries (ENPPI) • IMEC Company for Oil and Gas Services. • Egyptian Universities; Al Mansoura Universit,Fayoum University, Menofeya Utilities Data Center (MUDC), • Menofeya Governate,City of Scientific Research and Technological Applications, Alex.. • Suez Canal Authority , Ministry of Supply &Foreign and Akpa Company in the field of collecting used cooking oil. International Agreements • Al-Thurya Technical Training Institute in Kuwait • IFP ENERGIES NOUVELLES in France • College of Petroleum Engineering and Technology, Sudan University of Science & Technology, SUST-CPENG, Khartoum, Sudan • The African Village, Sudan • New Mexico University in USA • The Central Oil Labs – The Sudanese Establishment for Petroleum (Sudan) • Clausthal University of Technology, Germany. • Asawer Company for Oil and Gas, Ministry of Petroleum, Sudan. • University of Aberdeen, Tesla Lab. • Biofuel National Project, Ministry of Sciences and Communications, Khartoum, The Sudan. • Korea Research Institute of Chemical Technology (KRICT), The Republic of Korea. • Indian Institute of Science (IISc), Bangalore, India. • Centre of Emerging Technologies, Jain Global Campus, Jain University Jakkasandra ,India • A O.U. between SINOPEC Corp. Research Institute of Petroleum Processing. • A M.O.U. between Kuwait Institute for Scientific Research. EPRI Projects EPRI projects come as a fruitful result of researches for on the scientific ground. 1-Preparation and characterization of polymers used in fabricate of Ultrafiltration and Nanofiltration membranes for water treatment, funded from Egyptian Petroleum Research Institute (EPRI), 2018, 2020. 2-Preparation and Characterization of Polysulfone for Fabrication of Advanced Filtration membranes for water treatment, funded from Egyptian Petroleum Research Institute (EPRI), 2023

	3-Italy–Egypt joint science and technology cooperation (2023-2025), no 47547“Water Desalination by inverse-osmosis: new membranes fabricated by electrospinning and photoinduced crosslinking”, funded from Science and Technology Development Fund (STDF), 2024-2026. 4-Potential of Chitosan-Tannic acid biopolymer in treatment of Industrial wastewater, funded from Science and Technology Development Fund (STDF), 2018-2020. 5-Oil Quality Control Project to link research, development, and production, which provides the hard currency necessary for importing these chemicals from abroad and preserves the intellectual property of scientists and researchers. 6-Nanocomposite Polymers Project; a project of 10 million Egyptian pounds that seeks to create a multidisciplinary infrastructure to allow the integration of research and applications, in advanced engineering materials. 7- Non-Conventional Oil Recovery Project to retrieve an amount of the total stored heavy oil from the Egyptian fields or the amounts left after primary and secondary oil recovery. EPRI also has an improved production unit and improved lifting of the oil yield coefficient. It is completed with an investment of 20 million Egyptian pounds to study the extraction of heavy oil, estimated at 3 billion barrels in Egypt alone. 8-Heat Exchangers Cleaning Project, which cleans the water and thermal exchangers using innovative chemical and mechanical methods to solve the problems of all types of salt deposits. 9-The Corrosion Control Project also provides corrosion control programs for various oil companies, monitors corrosion rates using modern technology and advanced equipment to measure corrosion in oil installations and predicts their life span. 10-Cathodic Protection Project aims at linking scientific and applied research in the field of industry, especially in the petroleum sector, due to the problems encountered by the cathodic protection systems such as lines, installations or tanks, and platforms, which may cause disaster and waste of huge sums of money estimated in billions. Innovative projects 11- Paints Development and Production Project, which aims to develop and produce different types of paints, for the establishments according to international standards and specifications using local raw materials. 12- Controlling the Quality of Petroleum Establishments to obtain the highest possible quality of the petroleum facilities required by international standards and specifications –using the latest technologies reached by scientific and applied research. 13- (NDT)Project; This project is designed to examine the safety of oil tankers and their distillates from the outside without stopping the service to identify the weaknesses and strength in

	the fuel transport tanks to carry out preventive maintenance before the occurrence of transport accidents which cause great losses in money and lives.
Company strategic orientation	EPRI Strategic Plan: 1. Commercializing traditional scientific researches; to twin scientific research with industry. 2. Purifying the scientific climate: a) Providing infrastructure for EPRI labs. b) Supplying the workforce with needed equipment for production. c) Insuring youth minds against intellectual suppression seeking for their creativity. 3. Twinning EPRI with equivalent international institutes i.e. (cooperation with IFP) 4. Modern research trends: a) water desalination by advanced filtration membranes b) Establishment of applied geophysics research unit. c) Synthesis of diesel from plastic wastes. d) Production & storage of hydrogen. e) Nano-technology applications in petroleum sector f) Production of Biofuels from algae. g) Production of highly porous materials for catalysis.

SECTION 2: Spanish Company Profile *(Please provide a brief summary of the prospective partner company or organization. This summary may address some or all of the points below)*	
Profile of ideal technology partner	Preparation and characterization of tannic acid-crosslinked chitosan nanofiltration membranes coated on hydrolyzed polyacrylonitrile for water desalination and treatment
Core technological competencies and expertise	Synthesis and characterization of polymers of membranes, polysulfon, polyacrylonitril, polycellulose acetate, Chitosan, chitin, synthesis and characterization of ultra and nanofiltration membrane, polymer chemistry, water treatment.
Other essential qualifications (e.g.: ownership, track records etc.)	The Spanish companies which have an ownership (patents) as well as the track records (research papers, ...) of here works field is highly preferred
If you have a list of companies with whom you are in contact or interested in contacting, please provide contact details	I have No

If you are interested in collaboration: please specify details and other important information you want to share with a potential company	I. Fabrication of modified chitosan nanofiltration membranes 1- Fabrication of the desirable PAN ultrafiltration membranes based on Integrally Skinned Asymmetric (ISA) and phase inversion methods 2- Hydrolyzed the prepared UF membranes by NaOH solution. 3- Improvement the surfaces of prepared ultrafiltration membrane by coating with active natural polymer (chitosan) and crosslinking by different concentration of active natural compound (tannic acid) **II.** Characterization of the obtained membranes - Characterization of the membranes by Fourier-transform infrared spectroscopy (FT-IR), field emission scanning electron microscopy (FE-SEM) and atomic force microscope (AFM), thermal analysis, contact angle, Zeta potential, BET instrument, XRD and XPS. **III.**Testing the efficiency of the fabricated membranes for water desalination and treatment 1- Determination of permeation and rejection properties using operation pressures of 10-15 bars, mono and divalent salt solutions (2g/L) as aqueous feed solutions by reverse osmosis (RO) system lab scale. 2- Measurement of the antifouling properties using 100 ppm of Humic acid solution. 3- Determination of the efficiency of treatment of salty oil wastewater. **IV.** Measurements of chlorine resistance and antibacterial activities for obtained membranes 1- Determination of chlorine resistance properties towards 5% Na hypochlorite solution. 2- Evaluation of the antibacterial activities against gram negative and positive bacteria.
Interested areas of collaboration	Water treatment by advanced polymeric membranes, synthesis of polymers which used in fabrication of membranes
Specific R&D contribution you are seeking/offering	Improvement the advanced membrane prepared from tannic acid-crosslinked chitosan nanofiltration coated on hydrolyzed polyacrylonitrile for treatment and desalination of water

Hassan Hefni

Signature

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Date: 09/04/2025

Preparation and characterization of tannic acid-crosslinked chitosan nanofiltration membranes coated on hydrolyzed polyacrylonitrile for water desalination and treatment

Abstract

Desalination of seawater and purify the polluted water are the essential processes for to produce clean water for human, industrial, and agriculture uses. Current extraction and purification approaches suffer from the limitations on selectivity and efficiency. Hence, developing smart membrane with high efficiency, easier in controlling in shorter time with lower energy to produce clean water is the most challenging task. In this proposal, the treatment of water is based on fabrication of nanofiltration (NF) membranes via technique of coating and crosslinking thin film composite (TFC) membranes, using; chitosan as the active layer material, hydrolyzed polyacrylonitrile (HPAN) ultrafiltration (UF) membranes as the support membranes, and tannic acid as the crosslinking agent. The influence of chitosan concentrations, tannic acid concentrations, time and temperature of crosslinking processes on the performance and properties of membranes such as morphology, porosity, hydrophilcity, thermal stability, and antimicrobial activity will be studied. The molecular weight cut-off of prepared membranes using 1 g/L with different molecular weight of polyethylene glycol (200, 400, 600), as well as the assessment of the selectivity performance of prepared membranes using 2g/L from different di & mono-valent salts solutions will be investigated. In addition, the fouling and chlorine resistance of the fabricated membrane will be measured. The hydrolysis of PAN aims to increase the hydrophilicity properties, improve the pore structure, and compact the chitosan top layer with membrane surfaces. Tannic acid can interact between chitosan top layer groups, aims to decrease the roughness, improve the pores structures, antibacterial activity, and hydrophilicity.

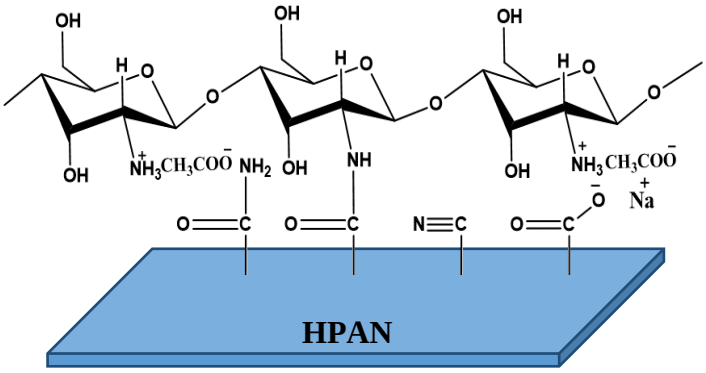
Overview

A shortage of water in the future would be detrimental to the human population, where one in eight people in the world do not have access to clean water. Fresh and unpolluted water accounts for 0.003% of the total water available globally. Water treatment is the essential process for purifying the polluted water to produce clean water for human,

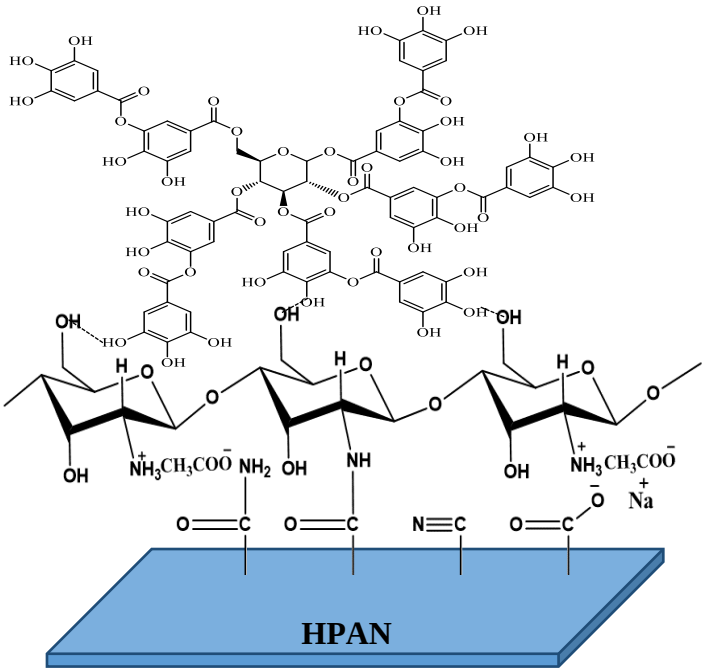
industrial, and agriculture uses. Water treatment from organic and inorganic pollution are achieved by different ways such as, electrochemical treatment, chemical precipitation, ion exchange, adsorption on activated carbon, and membrane technologies. Membrane technology is still the best technique for separation systems and water treatments. Due to its high efficiency, easiness in control and applications, compact design, low time, and energy consumption, and single-phase separation, no time is required for adsorption, desorption, or even regeneration [1-3]. The advantageous membrane should contain functional materials with different structures to ensure high permeation rate, high selectivity for different species, long and reliable lifetime, resistance to fouling, and sufficient resistance to thermal, chemical, and mechanical effects under operating conditions [4]. Membrane technology can be widely applied in different fields depending on its composition, such as water treatments, petroleum industry, pharmaceuticals, gas purification and separation, food processing, environmental protection, and medical applications [5]. The beauty of membrane research is that it is a dynamic process that is constantly evolving. Polyacrylonitrile (PAN) is well suited for the preparation of porous substrate membranes because it is highly acid resistant to various inorganic acids such as nitric acid, sulfuric acid, and hydrochloric acid, and is also inexpensive compared to other polymers such as polysulfone [6] and polyimide [7]. Hydrolysis of PAN is a good process to improve of its hydrophilicity, pore structure, and surface morphology [8]. Chitosan is advantageous because it is film-forming, biodegradable, and renewable. The tailor-made modification processes are expected to overcome the limitations in terms of fouling resistance, pH resistance, solvent resistance, and selectivity. Chitosan, the polyaminosaccharide, is a copolymer of N-acetyl D glucosamine and D glucosamine [9]. The critical functionality ($–NH_2$ at the C-2 position of D- glucosamine unit) has the unique advantage to modify. The modification approaches of chitosan are crosslinking, blending, composite, and grafting, which make it more attractive in terms of membranes [5, 10]. These strategies aim at improving the membrane performances by addressing the limitations such as fouling, pH, chemical stability, and separation [7, 11-13]. In a previous work [14], we fabricated nanofiltration membranes from chitosan-tannic acid crosslinked composite on PAN membrane via pores filing mechanism for water desalination. However, there were some limitations in this previous work such as chemical and thermal instabilities

of the fabricated membranes and low fouling resistance. In this proposal, it is believed that the combination of materials such as chitosan as active natural polymers, tannic acid as crosslinked, and hydrolyzed PAN as supporting ultrafiltration membrane could provide control over the obtained membranes in terms of their morphology, porosity, hydrophilicity, thermal stability and antimicrobial activity. Control of these properties is important to achieve highly efficient membranes for specific applications such as water desalination.

The expected obtained structure mechanism of this proposal as following:



Scheme 1 The interaction between HPAN and chitosan



Scheme 2 The interaction between HPAN and chitosan crosslinked tannic acid

References

1. Tang Y, Cai Z, Sun X, Chong C, Yan X, Li M, Xu J. Electrospun Nanofiber-Based Membranes for Water Treatment. Polymers (Basel). 2022, 13;14(10): 2004.
2. Kumarage, S.; Munaweera, I.; Kottegoda, N. A comprehensive review on electrospun nanohybrid membranes for wastewater treatment, Beilstein J. Nanotechnol. 2022, 13, 137–159.
3. Gazigil L, Er E, Kestioğlu OE, Yonar T. Pilot-Scale Test Results of Electrodialysis Bipolar Membrane for Reverse-Osmosis Concentrate Recovery. Membranes. 2022; 12(1):83.
4. Turek, Marian, Krzysztof Mitko, and Paweł Skóra. "Applying Nanofiltration to Decrease Energy Consumption and Sensitivity toward Feed Composition Fluctuations in Salt Production." Membranes 14, no. 5 (2024): 103.
5. Jafari Sanjari, A. and Asghari, M., A review on chitosan utilization in membrane synthesis. ChemBioEng Reviews, 2016, 3, 134-158.
6. Jia, Tian-Zhi, Jin-Peng Lu, Xin-Yao Cheng, Qian-Cheng Xia, Xue-Li Cao, Yong Wang, Weihong Xing, and Shi-Peng Sun. "Surface enriched sulfonated polyarylene ether benzonitrile (SPEB) that enhances heavy metal removal from polyacrylonitrile (PAN) thin-film composite nanofiltration membranes." Journal of Membrane Science 2019, 580: 214-223.
7. Kononova SV, Kuznetsov DA, Gubanova GN, Kruchinina EV, Volkov AY, Vylegzhanina ME, Vlasova EN, Volchek BZ. New Membrane-Forming Aromatic Co-Poly(amide-imide)s: Influence of the Chemical Structure on the Morphological, Thermal and Transport Properties. Membranes. 2022; 12(1):91.
8. Xu, Dong, Guangyao Pan, Yutong Ge, and Xuan Yang. "Preparation of a low-protein-fouling and high-protein-retention membrane via novel pre-hydrolysis treatment of polyacrylonitrile (PAN)." Membranes 13, no. 3 (2023): 310.
9. Hefni, Hassan HH. "Functional chitosan surfactants for corrosion inhibition in petroleum industry." International Journal of Biological Macromolecules (2024): 134704.
10. Bhattacharya, A., & Hefni, H.H.H. (2025). Chitosan Membranes (M.K. Mishra, Ed.). *CRC Press.* https://doi.org/10.1201/9780367694265-EPPMPT43-1
11. Li, Shao-Lu, Yaxu Guan, Yiwen Qin, Youcai Chen, Dandan Cheng, Genghao Gong, and Yunxia Hu. "An antifouling loose nanofiltration membrane prepared by cross-linking HPAN ultrafiltration membrane with zwitterionic polymer PEI-CA for efficient dye desalination." Desalination 549 (2023): 116354.
12. Jain, H.; Garg, M.C. Fabrication of polymeric nanocomposite forward osmosis membranes for water desalination—A review. Environ. Technol. Innov. 2021, 23, 101561.
13. Tian, X., Yu, H., Yang, J. et al. Preparation of reverse osmosis membrane with high permselectivity and anti-biofouling properties for desalination. Front. Environ. Sci. Eng. 2022, 16, 89.
14. Hefni, H.H.H., Saxena, M., Mehta, R., Bhojani, G., Bhattacharya, A.Chitosan/polyacrylonitrile composite nanofiltration membranes: towards separation of salts, riboflavin and antibacterial study. Polymer Bulletin, (2022) 79:4339–4360.