Department of Membrane & Sorption Processes & Materials

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Offer

«Industrial manufacture inorganic ion-exchange materials and technologies development, connected with this products»

Kiev

The developments of our institute are based on the newest technologies and acknowledged by the world scientific society. They allow realizing both scientific researches and technologies in the different fields of industry.

The main area of our scientific activity is development and manufacturing of the granulated multifunctional inorganic materials based on compounds of zirconium, titanium, aluminum, tin, and also oxide and phosphate materials with high purity grade.

The main areas of activity:

- scientific-research activity to develop new inorganic materials, which are synthesized by the original sol-gel technology.
- scientific-research and development activity aimed on purification of liquid and gaseous media by new methods.
- Manufacturing of non-standard (mobile and stationary) equipment for water purification.

The developed in our department under cooperation with SDPD of the V.I.Vernadsky Institute of general and inorganic chemistry ion-exchange materials are composite inorganic materials based on zirconium, titanium, aluminum and tin hydroxides, oxides and phosphates.

A new sol-gel technology allows the commercial manufacturing of these inorganic materials in the form of spherical granules, which advantageously differs them from the known analogues.

- Areas of application:
- Nuclear industry
- Potable water purification
- Purification and stabilization of wine
- Power engineering (catalysis)

The world water consumption reaches 4 trillion m^3 a year. The harmful chemical elements and compounds turn into the water reservoir and make its sanitary state worse. Such water requires the special deep purifications before using for potable and industrial purposes.

Many impurities can’t be removed from the mechanically, can’t be neutralized by biological purification, can’t be removed by means of such purification methods as sedimentation, coagulation, flotation, reverse osmosis, evaporation, electrodialysis. It sets conditions to develop a new complex technological scheme of water treatment.

Since the considerable amounts of stable impurities come into the water reservoirs with industrial, agricultural and domestic wastewaters, their purification and recycling is very important from the point of view of economy and ecology.

The heavy metals are attributed to the impurities with accumulative activity and specific toxic properties. Many metals generate so-called synergistic mixtures, which cause much stronger toxic effect on water organisms, then the total effect of individual components.

That is why the freshening of drainage waters, desalination of vent, surface, wash, mine and other industry waters, development of non-waste schemes of water treatment and recycling systems with feeding water desalination are the effective solutions of this problem, where the combination of ion-exchange and electrodialysis plays key role.

The insoluble metal phosphates (first of all: zirconium and titanium phosphates) should be sorted out from the wide spectra of inorganic ion-exchange materials due to their high ion-exchange capacity, thermal and radiation stability and high sorption selectivity of cesium, strontium, mercury and cadmium ions. The insoluble salts of poly- and heteropolyacids: molybdophosphates, tungstenphosphates etc., which possess selectivity towards rare alkali, earth-alkali and heavy metals, also should be mentioned.

Nuclear power

A lot of liquid radioactive wastes (LRW), which must be utilized, have been accumulated in the world during development of nuclear industry for citizen and military purposes. As a rule LRW is the mixture representing different types of chemical impurities. In LRW water is the media, which contains coarse dispersed components and soluble low- and high-molecular compounds. Radionuclide is usually present in all types of waste waters, and that is why any technological scheme must supply separate removal of each mentioned above impurity. The pollution of fresh water by radionuclide and industrial wastes resulted in necessity development of technology for their deactivation and purification. Many organizations develop and suggest purification technologies of high salts containing water. The difficulty lies that the most effective ion-membrane methods need materials, which corresponding to the very high requirements. The large amount of such materials were developed and tested only in laboratory or pilot conditions, but without using in industry. Only single examples of ion-exchange materials are available for commercial application, but the high prime cost limits their demand.

Selective removal of radionuclide can result in considerable costs saving of different liquids purification. It also allows changing their radioactivity class for further purification by cheaper methods to reach the maximum allowable concentration of salts and dispose them. Changing radioactivity class by selective radionuclide removal can take place of vitrification, which requires considerable energy consumption.

We suggest the new way, concerning treatment processes of radioactive liquid media, processing lines for its realization and ion-exchange materials for selective removal of radioactive metal ions.

These processes, lines and ion-exchange materials can be successfully used to remove such long-lived isotopes as ^{137}Cs, ^{60}Co, ^{90}Sr, which usually appear in the cooling system of nuclear reactors as a side product.

We have solved the problem how to synthesize low-cost highly selective ion-exchange materials stable for thermal, chemical and radiation exposure. Such ion-exchange material possesses high ion-exchange capacity, which almost doesn’t depend on presence in LRW ions of cobalt and other non-alkali metals.

The additional advantage of our highly selective ion-exchange material is that it is completely inorganic and can be used in many processes, especially where organic materials can’t be used.

Potable water purification

The treatment of high quality potable water is the problem of all countries. Water impurities are under control, their composition and concentration is standardized. There are 6 groups of such impurities: organoleptic, generalized, inorganic, organic, biological, radiological. The total number of quality indexes is over 50, but only part of components permitted to be present in the water source depending on region.

The plants for water treatment are very bulky and their operating is expensive. In small communities the water treatment scheme is simplified. In USA, for example, ion-exchange resins or mineral adsorbents are used for water softening and then ions content conditioning is carried out. But it is not possible to obtain water with necessary taste and this scheme also requires regular filter regeneration and wastes utilization.

Membrane and sorption technologies play an important role in water treatment processes. Membrane filtration and reverse osmosis are usually used today.

Electrodialysis is also attitude to membrane technologies. Desalination takes place due to ions migration in concentrating compartments under the effect of potential gradient. The advantages of electrodialysis in comparison with other schemes of water treatment are obvious:

- No chemical reagents and solutions after regeneration of ion-exchanger;
- Continuity of the process;
- Possibility to adjust the depth of desalination.

The high desalination is supplied by the intermembrane filler, which represents ion-exchanger with enhanced selectivity towards ions of hardness and non-ferrous metals.

When choosing the method of desalination the key role belongs to expense of process, which includes investments and operating costs. It is interesting to compare the expense of each method of desalination and display the area of their application.

Parameter	**Ion exchange**	**Reverse osmosis**	**Electrodialysis**	**Electrodeionization**
Reliability	3	2	1	3
Desalination extent	3	2	1	3
Removal of organic substances	1	3	1	2
Removal of dredge	1	3	1	2
Requirements to pretreatment	3	1	1	2
Energy consumption	3	1	1	2
Reagents expense	1	3	3	3
Expense of feeding water	3	1	1	3
Possibility of waste disposal	1	3	2	3
The average parameter of effectiveness	4.2	4.3	2.6	5.1

The model of sorption-membrane electrochemical unit has been developed. It is set for effective required water desalination with complete removal of toxic ions and undesirable impurities. All components of unit are represented by functionalized inorganic materials, which are stable in aggressive media and are not poisoned by pollutants.

The main component of such unit is ion-exchange sorbent, which is able to remove both cations and anion simultaneously, i.e. to desalination process. As much attention is paid to water softening, these ion-exchangers must possess higher selectivity towards hardness ions. There’s also necessary high selectivity towards ions of toxic metals (such as Cd(II), Cr(IV), As(V)) and high mobility of adsorbed ions in the bed of ion-exchanger under the gradient of potential. Realization of these requirements supplies continuous non-reagent regeneration during water desalination by means of electrodeionization method.

The aim of this project is design, development and test of the pilot unit for water treatment in conditions of the small communities.

The final result of the project is commercial manufacturing of competitive units for water treatment by electromembrane method.

The individual approach is used for each object. Development of technological scheme is carried-out with Customers participation. Whole parameters of unit operating are taken into account. The choice of technology depends on quality requirements to the final product and its expense.

Purification and stabilization of wine

Electrodeionazation technology, where new materials based on zirconium phosphate are used, gives a large opportunity in water treatment for alcohol products manufacturing.

Wine industry

"Tartar – crystals, which are deposited on the wall of tuns, vats, bottles and form the firm crusts.

The tartar can be generated under exposure to cold or mechanical state (in some white wines).

The quality and taste of wine is not changed, but there are some difficulties with bottle opening due to the tartar, and part of bottle content can be lost after uncork."

http://www.wineworld.ru/voc/article325.html

We suggest the sorption technology of wine stabilization against calcium dimness, caused by excess of calcium. Besides, this technology supplies effective potassium, heavy and toxic metal, radionuclide removal.

This sorption technology is based on new inorganic sorbent, representing insoluble polymer – zirconium phosphate. By means of sol-gel technology this sorbent can be obtained in form of mechanically durable granules, which are stable to abrasion, possess good kinetic and capacity characteristics.

After metal ions removal their salts are substituted to corresponding acids (tartaric) and sodium salts, which don't cause dimness. This sorbent is cation-exchanger and that is why it doesn't absorb organic components from wine.

The treated volume of wine in one stage of sorption is calculated to achieve average calcium concentration around 80-90 mg/dm^3, which allows avoiding dimness. The treated wine of wine material is gathered together, averaged (mixed) and is used in further technological purposes as one group.

Vodka industry

The improvement of vodka quality, using inorganic adsorbents has been developed.

Adsorbents provide the alkalinity decrease and stabilize neutral of weak-alkali pH value. They also afterpurificate vodka form hardness salts, ammonia, heavy metals (iron, manganese, led, chromium, zinc, etc.), radionuclide and organic impurities (aldehydes, ethers and long-chained alcohols).

Adsorbents also provide secondary smell removal, improve organoleptic indexes and soften the taste of vodka.

Zirconium vodka is a unique product, which assists radionuclide removal. The treated by original technology water, developed by Ukrainian scientists, doesn't contain ^{90}Sr, ^{137}Cs and hardness ions. Soft taste and strength of drink give unforgettable feelings.

Energetic (catalysis)

Elecrtochemical method of hydrogen generation, separation and accumulation is one of the most promising methods in hydrogen energy. Wide use of hydrogen in fuel cells accentuates importance of this direction to solve the most important problems of energy industry. We suppose to investigate and introduce the series of new materials for generation and accumulation of hydrogen. The necessity of this direction is caused by low effectiveness of natural gas, which may result in crisis of country economics. The search of new energy sources therefore is very important.

The coke plants are the biggest hydrogen fabricators in Ukraine. The year coke gas generation gives 10 billion m^3, which contains 58-62% of hydrogen. At the same time 5 billion m^3 is used for internal needs of plant; 1,5 billion m^3 is a commercial product and 3,5 billion m^3 of coke gas is burned.

Electrochemical systems with catalytic materials could be used as alternative hydrogen sources with high purity grade. Metal oxides are promising materials, which are widely used as catalysts of chemical reactions and in electrochemical hydrogen generators. We can give a number of such materials for tests.

New high effective and selective catalysts, their carriers and new hydride generating materials are required to solve the problem of generating and accumulating of hydrogen. These inorganic materials will be used for as catalyst for hydrogen release and its accumulating in these materials. Carbon nano-tube (CNT) is the promising material, which can be used as a carrier of catalysts for different catalytic processes. Existing method of CNT obtaining are very expensive, one kg of the cheapest nano-tubes cost $ 800. We suggest reducing the price of CNT using catalytic pyrolysis for their obtaining. Modification of CNT by catalytic metal particles gives new unique opportunity to generate and accumulate hydrogen.

Economy analysis has shown that effectiveness using of inorganic membrane will be worse only if they cost 180 times higher than organic membrane. Taking into account, that the price of non-porous polymer fibrous materials is around $5-20 per m^2, the effective price of hydrogen-permeable inorganic membrane is in the range of $ 900-3600 per m^2. The calculated price of our material, including industrial manufacturing, is $600-900 m^2.