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CHEMISTRY AS A BASIS FOR SOLVING ENVIRONMENTAL ISSUES

Vadim E. KOGAN, Tamara S. SHAKHPARONOVA
Saint-Petersburg Mining University, Saint-Petersburg, Russia

The article summarizes over 40 years of authors' experience in the field of physical chemistry and chemical technology of glassy state of materials. It is shown that environmental issues are caused not by Chemistry as a science but by actions of ecologically illiterate humans using its advances. It is noted that without chemistry humankind cannot live comfortably and solve existing environmental problems. In support these facts we describe several developments made by authors of this article in energy industry, high temperature machinery, glass production technology, glassy phosphate fertilizers, production of non-waste systems and complex research of physical-chemical principles of glassy oil sorbents production of organic and non-organic nature.

Key words: ecological safety in power energy, non-standard thermal engineering units, glass technology, glassy phosphate fertilizers, non-waste production, glassy oil sorbents of organic and non-organic origin

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Introduction. One of the current global issues is transformation of natural systems and ecologically safe development of mineral resources. The significance of footprint problems is confirmed by the fact that the president of Russian Federation V.V.Putin on 10.08.2012 signed the Executive Order N 1157 «On holding the Year of the Environment in Russian Federation in 2013», and on 05.01.2016. he signed the Executive Order N 7 «On Holding the Environment Year in Russian Federation in 2017».

Major current environmental issues are caused by different chemical processes. That is why chemistry is considered to be a reason for ecological imbalance in nature. However, without chemistry a humankind cannot live comfortably and what is more important – solve existing ecological issues.

This article is devoted to examination of several developments of its authors resulting from over 40 years of research and practical activities in the field of physical chemistry and chemical technology of glass state of substances, which are the clear evidence for all mentioned above.

Research results and discussion. The safety of energy facilities exploitation is the key criterion for energy generation process. Emergency cases has huge negative effect on environment and can be referred as ecological safety issues.

The reliability of power lines is provided by electrical systems and units isolation techniques, such as adequate choice of insulator type at the power line designing stage. The construction process of Asuanskaya HPS, which was commissioned to operation in summer of 1967, showed that glass is indispensable material that is reliable under conditions of high mechanic and electric loads as well as in corrosive medium. However, the composition of glass types used in production of electrical mass products including high-voltage insulator is quite limited today.

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The development of glass composition for high-voltage insulators has been started by authors of this article in the beginning of 1970-s, i.e. they were pioneers in this field. These developments based on complex physical and chemical technology research of glass types were always aimed at studying not only unfailing performance of produced items, providing ecological safety in energy industry but on economic efficiency improvement too. The last was achieved through production of glass out of natural raw materials: minerals (sand, perlite sand, limestone), ores (second-class black iron ore) and their concentrates, as well as waste materials (barytic waste from dumps).

The example of this type of development is glass with composition PP-80 considered in depth in a paper [7]. It should be noted that glass has good workability characteristics. It is slightly worse than glass produced in Lvov used for production of electric insulators with volume resistivity at 20 °C, glass PP-80 has better puncture strength and lower values of dielectric loss factor, which significantly influence its smaller sizes, weight and price. The specific feature of this type of glass is its high corrosion resistance that widens its application range.

Common electric insulating silicate materials (glass, porcelain, etc) has weak spot, i.e. low heat-resistance and impossibility of mechanic processing with usual carbon cutting tools. Thus, the practical task of our developments started in 1975 was production of materials with high dielectric and mechanic parameters, heat-resistance (including cyclic loads) and mechanic processibility (cutting, drilling, milling threading, etc) with usual carbon cutters.

Our studies (described in paper [15] in details) led to development of glass-mica crystal compositions produced according to glass production technology out of molten mass sweating as liquid-crystal. Such materials have high compressive strength (up to 314 MPa), enhanced heat-resistance to cyclic loads (up to 100 cycles of 0 – 500 – 0 °C), volume resistivity of 10^4-10^9 Om·m, working temperature not less than 850 °C in corrosion media, zero porosity and mechanic processibility with carbon cutters (coverage rate up to 20 mm/s).

These materials are successfully used for special insulators production, resistive elements, units of glass furnaces and secondary heat treatment furnaces for flint glass processing, wafer-plates and chlorinators for manganiferous materials in flux of manganese tetrachloride. They provide trouble-free operation of different units and promote ecological safety.

The ecological problems escalate because of different types of production waste annually accumulated in stockpiles. The main tool for solving this issue is to find a way to use waste materials (creation of non-waste technology). Previously we described such example – usage of baryte waste in production of PP-80 glass. There is one more example of non-waste technology – method of producing mono-focones from quartz glass developed by us and described in paper [17], it is based on reaction of quartz glass with fluxes and solutions of fluorides. In case of cadmium fluoride flux the disposal flux was used for production of glass-crystal substance, that could be processed with carbon cutters, and photochromic glass, i.e. we had implemented non-waste production principle.

All the above-mentioned examples are related to production of glass and glass composite materials and connected to high temperature processes.

The glass production industry is one of the ecologically unsafe and is one the second place by the energy density spent on production of one unit after aluminum production industry. That is why new technology in this field should be aimed at ecological safety and energy efficiency of production processes.

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At the current state of high temperature production processes the ecological safety include a set of tasks, we can single out three major ones: ecological cleanness; energy efficiency; flexibility as a possibility to produce a wide range of products and use it in other industries.

We have been investigating these tasks for more than 30 years and can conclude that the most prominent results are achieved in development of non-traditional heating units enabling implementation of all the described tasks without lowering the quality of final product.

One such heating units is our model of glass furnace called IK-1 and its several modifications described in paper [8]. The design of this furnace and its modifications provide ecological cleanness of production process because of abrupt (up to ten-fold times) reduction of components volatility and energy intensity (up to ten-fold times) of high-temperature processes and possibility to run several processes in one furnace. The design of this furnace is flexible and multifunctional.

Our another non-traditional heating unit described in paper [14] is a heating chamber for glass cylinder raw parts drawdown for production of self-focusing optic elements and fibers. The chamber can be equipped with sources of radiant energy such as infrared incandescent lamps and ultraviolet heaters with emission wave length equal to absorption wave length of used glass type, which provides ecological cleanness of production process.

One of the key factors providing transformation of natural systems and development of mineral resources without ecological damage is rational use of mineral resources. This issue was described in paper [5], which is partially devoted to development of ecologically safe glassy fertilizer of prolonged action and restoring natural resources, and its industrial use and wide application in agricultural chemistry.

The population of our planet constantly grows and we need more food including vegetables. However, we cannot enlarge the number and area of planted acreage across the globe. That is why we need to think about fast and large increase of crop yield, that is possible only with timely balanced feeding of plants. Besides the crop yield we have to think about rational and science-based usage of land resources. And here we face a problem of land crop-producing power restoration especially the ones that are no longer usable for yield, their rehabilitation requires complex, long-time and expensive reclamation activities.

The solution of all above-mentioned issues is clearly impossible without fertilizers. The fertilizer developers and manufacturers (organic and mineral ones) have to strive for finding solution to a challenging but resolvable problem – production of additives for crops without existing disadvantages of fertilizers irrespective of their origin. Finding solutions for this issue has great social and economic significance and has to promote the development of an inexhaustible source of technically and economically viable products for restoration, conservation and increase of land crop-producing power as well as provision of green environment.

The objective assessment shows that main disadvantages of major types of industrial and widely used mineral fertilizers are connected to their poly-crystalline structure causing fast dissolving, washing out and weathering, and finally selective leaching by ground waters. Washing and weathering result in situations when fertilizing does not lead to feeding of plants but even to worsening of water basins environment.

The authors of paper [5] note a dramatic way of overcoming these disadvantages, that is refusal of common poly-crystalline fertilizers and development of completely new highly efficient fertilizers based on non-crystalline materials like glass. The targeted development of glass compositions for mineral fertilizers production industry and large-scale production

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[2, 9, 10] have not been considered before the implementation of the project [5]. The project resulted in development of competitive Russian materials and technology for production of ecologically safe glassy fertilizer of prolonged action «Agravitakva-AVA» and its different modifications, which promotes natural resources rehabilitation.

In 2000 Glass production plant «Svetlana» in Malaya Vishera (currently OOO «Svetlana-Malovishersky stekolny zavod») was the first one in the world to synthesize phosphate glass (fertilizer AVA) in glass furnace under the supervision of professor V.E. Kogan. Current achievements and results are provided in paper [5].

During synthesis of phosphate glass, it was noted that functionality of the resulting product AVA is far beyond the fertilizer material. As it is said in paper [5], during very dry summer in Malaya Vishera, they had yield of pepper «Lastochka» was only at the areas where they used this type of fertilizer. The experiments showed that cucumbers can be grown directly on the produced glass. In the area of Chernobyl APS they grew strawberries crop and it didn't have the radiation in places where they used AVA fertilizers. This is another field for research and practical use of phosphate glass for solving ecological issues.

The development of oil production industry leads to oil spills and other types of contamination in regular situations, they also have more emergencies during transportation of oil and petroleum, the most dangerous ones are in case of water transportation.

In paper [8] it was noted that there was developed a new type of bio-absorbent for clearing oil spills on water surfaces, this material is an association of stocks – carbon decomposers immobilized on porous drying agents – foam glass produced from ultrafine fraction of glassy phosphorous fertilizer. Speaking about this bio-absorbent and bio-sorbents in general [13], it should be noted its disadvantages: modest floatability, possibility to use it only with temperatures above 8 °C, storable life of 2 years and inability to use it for emergency spills because of lack of required performance function. Currently we have found the solution of floatability problem but other disadvantages are still relevant.

Since 2012 professor V.E. Kogan has been supervising complex research of physical and chemical principles of production of glassy oil sorbents of organic and non-organic nature and their absorption processes and performance. These studies have been done at department of General and Physical Chemistry of Mining University. In particular, we produced almost insubmergible oil sorbents on the basis of AVA glass. The results of these complex research are shown in several publications (for example, [3, 4, 11, 12, 16, 18, 19]) and are summarized in paper [6].

We would like to highlight some results within the context of this paper too.

For developed oil sorbents based on phosphate and silicate foam glass we offered regeneration methods enabling high multi-usage of this materials and partial return of absorbed oil. The used sorbents can be returned into initial production process.

In case of phosphate systems regeneration is based on the fact that their compositions are of glassy AVA fertilizer type [5]. For system of developed foam glass matching the requirements for oil sorbents [1], their regeneration process was done by placing used sorbents with oil on ground and covering them with associations of stocks – carbon decomposers. After that the sorbent can be used again as sorbent or fertilizer.

Regeneration of oil sorbents based on silicate systems is grounded on low linear thermal expansion coefficient of basic glass S52-1, which makes it resistant to cyclic heat loads. This allows using oil burning process for sorbent regeneration. As a result a part of oil was de-

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sorbed and another part was burnt. We have conducted lab experiments with regenerated sorbent with 30 reuse ratios. After 30 cycles sorbent didn't have any visual signs of destruction, i.e. this reuse ratio is not a final value. This type of sorbent does not have to recycled. The laboratory experiments showed that 40 % of mass weight can be used as broken glass for production of glass S52-1, and 10 % – for production of oil sorbent from glass S52-1. Thus, the developed oil sorbent enables implementing continuous cycle and non-waste production. This fact promotes reduction of oil sorbent delivered to places of probable oil spills like oil tankers and ships and enables placement of self-contained equipment for sorbent regeneration directly at the place of oil spill.

Conclusion. The described developments have been made by the authors of this article within last 40 years of their scientific and production experience in the field of physical chemistry and chemical technology of glassy state of materials, which proves that chemistry is not a reason and fault of all ecological issues. Environmental safety problems are caused not by chemistry as a science but by illiterate people using its advances. Without chemistry humanity cannot live in comfort and solve existing environmental problems.

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***Authors*: Vadim E. Kogan**, *Doctor of Chemical Science, Professor vek51@list.ru* (*Saint-Petersburg Mining University, Saint-Petersburg, Russia*), **Tamara S. Shakhparonova**, *Candidate of Chemical Science, Associate Professor, 52tamara@mail.ru* (*Saint-Petersburg Mining University, Saint-Petersburg, Russia*).

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