USE OF PHOSPHOGIPS IN SILICATES

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ABSTRACT

Today, as in the rest of the world, our country needs to use waste as secondary raw material. Of course, this is due to the growing demographics and the declining supply of ore-rich raw materials. In this era of trends, finding helpful solutions for the use of phosphogypsum and its introduction into the industry is always relevant. Here are some results of this problem and discuss the possibilities of using world experience.

Keywords: phosphoric acid, wet process, phosphogypsum, compost, ceramic filler.

Phosphoric acid (H₃PO₄) is produced from phosphate ores by wet or thermal methods. The world’s 80% of phosphoric acid obtained by the wet process. The wet method involves chemical reactions, filtration, and evaporation (increasing the concentration). The phosphate rock is first ground and mixed with sulfuric acid in a reactor vessel. As a result of the reaction, tricalcium phosphate of the phosphate rock convert into phosphoric acid and an insoluble salt called gypsum, calcium sulfate (CaSO₄).

\[
\text{Ca}_3(\text{PO}_4)_2\cdot\text{F} + 5\text{H}_2\text{SO}_4 + \text{nH}_2\text{O} = \\
5\text{CaSO}_4\cdot\text{nH}_2\text{O} + 3\text{H}_3\text{PO}_4 + \text{HF}↑
\]

Keeping the concentration of sulfuric acid at 93-98% affects the reaction rate and crystallization of gypsum. In addition, controlling the concentration of sulfuric acid reduces the energy demand for evaporation and ensures optimal production.

The next step is filtration, in which solids are separated and washed. Finally, the extract is evaporated to obtain commercial phosphoric acid. High levels of phosphoric acid used in the food, pharmaceutical, and cosmetic industries will need to be refined [1]. The production of phosphoric acid from natural phosphate rock by the wet method results in an industrial by-product called phosphogypsum (PG). The production of one ton of phosphoric acid produces about 5 tons of PG and provides an increase in PG reserves worldwide of 100-280 million tons per year. This additional product is disposed of without any processing, mainly by disposing of large stocks. These areas are usually located in areas close to phosphate acid plants, which occupy large areas of land and cause serious damage to the environment. Phosphogypsum is mainly composed of gypsum, but also contains high levels of compounds such as phosphates, fluorides and sulfates, natural radionuclides, heavy metals, and other trace elements. All this hurs the environment and places many restrictions on the widespread use of PG. Up to 15% of PG in the world is used as additional raw material in the production of building materials, soil modification, and the production of Portland cement (Table 1). In particular, the use of PG is prohibited in many countries. The US Environmental Protection Agency classifies PG as a “Technologically Enhanced Naturally Occurring Radioactive Material” [2].

Radioactive substances found in nature are found everywhere throughout the earth's crust; mining, ore processing, fuel extraction, and other industries. The presence of radioactivity in the waste increases the risk of human exposure. The chemical industry can emit large amounts of radioactive substances into the environment, which leads to the spread of radiation. These industries include mining, phosphate processing, metal ore processing, heavy mineral sand processing, pigment production, fuel extraction and combustion, construction materials, thorium compounds production, aviation, and scrap metal processing [3].
Ants were grown in the fields and some... 4.

References

To increase the bending strength of the slab, glass fibers were added in conjunction with PG and the experimental inspection determined the optimal amount of water, fiber content, compression pressure, and compression number. Using an intermittent pressurized hydration process, phosphogypsum and fiberglass-based non-combustible tiles were produced for optimal ratios. The mechanical and durability properties of the phosphogypsum and fiberglass coated tile were tested. The main component of PG is CaSO$_4 \cdot 2$H$_2$O, which is well compatible with glass fiber in the hydration process. Phosphogypsum and fiberglass-based tiles have also been found to be slightly more acid-resistant than traditional tiles [7].

In addition to the above, PG can be used as additional raw material and filler in many other areas. Examples, the use of phosphogypsum to improve the sorption capacity of ceramic composites, the use of clay as a binder, and the use of ceramic glass [8].

In short, the efficient and economical use of industrial waste is a task of economic and social importance. At present, the use or recycling of phosphogypsum remains a problem for new or existing chemical plants. Although a lot of scientific research has been done in the field of complex processing of raw materials and some achievements have been made, the problem of using phosphogypsum is still on the agenda. Many world experiments using PG have been discussed and analyzed above, and the results have been presented. Of course, it is not possible to use them 100%, but it is advisable to apply them to the development of the most effective solutions.

Table 1. Chemical composition of raw materials in cement production [4]

<table>
<thead>
<tr>
<th>Components</th>
<th>Phosphogypsum</th>
<th>Shale</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>30.45</td>
<td>5.05</td>
<td>50.81</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>9.50</td>
<td>35.34</td>
<td>7.67</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>2.80</td>
<td>14.21</td>
<td>2.41</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>0.90</td>
<td>5.23</td>
<td>1.15</td>
</tr>
<tr>
<td>SO$_3$</td>
<td>42.9</td>
<td>0.15</td>
<td>0.26</td>
</tr>
<tr>
<td>MgO</td>
<td>0.30</td>
<td>1.88</td>
<td>0.57</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>0.10</td>
<td>0.30</td>
<td>0.16</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>0.63</td>
<td>0.11</td>
<td>0.29</td>
</tr>
<tr>
<td>LOI</td>
<td>12.42</td>
<td>37.73</td>
<td>36.68</td>
</tr>
</tbody>
</table>

In many coastal countries, industrial by-products are located along the coast, resulting in marine changes. Phosphogypsum is also a solid by-product formed in the production of phosphoric acid using similar traditional synthesis methods. Dissolution of raw phosphorite, which is about 50 times more radioactive than ordinary soils, in dilute sulfuric acid produces the primary product, phosphoric acid, and additional phosphogypsum. Reactive hazardous elements and natural radionuclides bind to PG. An insignificant portion of PG is in the form of nanoparticles (<0.1 μm). However, PG is a harmful by-product in many countries [5].

Due to the high content of phosphate, sulfate, and calcium in phosphogypsum, there have been several attempts to change it from soil to soil. In particular, PG was used in composting. Composts are produced by mixing olive oil and coffee bean waste into PG. Two concentrations of PG were tested, and composts formed after fermentation were used in field experiments to grow potatoes. The plants were grown in the field and composts were added as fertilizer and compared to commercial compost and cattle manure. Yields of potatoes grown in composts with the addition of phosphogypsum increased by 55.17% and were recommended for use in the production of high-quality food products [6].

There are also opportunities to use PG in the production of environmentally friendly non-combustible ceramic wall tiles. In particular, the possibility of using phosphogypsum as a binder in ceramic tiles is given below. To increase the bending strength of the slab, glass fibers were added in conjunction with PG and the experimental inspection determined the optimal amount of water, fiber content, compression pressure, and compression number. Using an intermittent pressurized hydration process, phosphogypsum and fiberglass-based non-combustible tiles were produced for optimal ratios. The mechanical and durability properties of the phosphogypsum and fiberglass coated tile were tested. The main component of PG is CaSO$_4 \cdot 2$H$_2$O, which is well compatible with glass fiber in the hydration process. Phosphogypsum and fiberglass-based tiles have also been found to be slightly more acid-resistant than traditional tiles [7].

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