KALCIJUM-HIPOHLORIT: INOVATIVNI UREDJAJ ZA PROCES NEUTRALIZACIJE VISOKO TOKSICNIH SUPSTANCI

CALCIUM-HYPOCHLORITE: INNOVATIVE DEVICE FOR THE PROCESS OF NEUTRALIZING OF HIGHLY TOXIC SUBSTANCES

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Abstract: In condition of application CB (Chemical and Biological) armour, by CB accidents and CB terrorism, at remove the consequence of contamination, one of the principal activities is doing single, group or final decontamination. For this purpose, kaporit (calcium hypochlorite) in water solution is, we believe, the most frequently used material. This is an anorganic substance with active chlorin. When solution is properly prepared, it is very useful, economic, effective and universal for decontamination and desinfection activities. Production of this material is consisted of finding reproduction material, collection of this material and needed equipment, quantifying, preparing the production area together with needed apparatus, solution production, effectiveness control, and finally, the use of made product. Technology depends on quality and quantity of reproduction material in disposal, apparatus and equipment, workers education, business organisation and protective measures during the working process.

1. INTRODUCTION

Should the significance and value of calcium hypochlorite in the state of war (the use of chemical and biological weapons), in accidents and in chemical and bio-terrorism be taken into account, it is very important to enlarge the number of manufacturers of this substance in the country who would be independent and use their own capacities, provide the necessary quantities of it and accomplish great financial savings. The substance in question is used as a 5-10% solution in water, as a mash (ratio 1:2) and as a powder (approximately 300g/m²). There are several factories in our country that produce chlorine and hydrated lime and the consumers are all the water supply networks and construction companies, hence both products are available on the market in adequate quantities. The mass production of the apparatus for the production of the solution Ca(OCl)₂ and its distribution into the CBR and CD protection units and into the companies and the personnel training (PTC NBC-D) are necessary. Obtaining the solution Ca(OCl)₂ includes procuring and collecting the means and the raw materials, determining the quantity of the solution and its use, adapting the working space and the apparatus required, the mere process of production, determining the efficiency when used in decontamination purposes and the use in removing the results of chemical and biological contamination. The technical proceedings depend on the quantity and quality of the means and the equipment available, qualifications of the personnel, work organization following the safety measures for the certain jobs.
2. **EXPERIMENTAL**

Technical chlorine causes burns when it reaches the skin. In the warehouses and in the mobile packages chlorine is in balance with its pair in liquid state. Chlorine dissolves well in water (1 volume part of water at 20°C and normal atmospheric pressure dissolves 2,3 volume parts of chlorine). Humid chlorine causes corrosion of steel and during the production of chloride great care must be taken in removing humidity using concentrated sulfuric acid. Dried gaseous chlorine may contain 50-150 mg/m³ of humidity or 10 to 170 weight ppm. Chlorine is one of the most reactive elements so it gets bound in the common temperature; even faster in the heightened temperatures, with all the elements at extremely heightened temperatures. When it comes to metals, with chlorine react most strongly (metals and main groups of periodic table elements) alkaline metals. The second main group of elements of the periodic table (alkaline earth metals) reacts almost as fast as alkaline metals.

For example: \[ \text{Ca} + \text{Cl}_2 \rightarrow \text{CaCl}_2 + 793.4 \text{ Kj} \]

*Figure 1. The apparatus for obtaining the caporit solution.*

1-chlorine bottle, 2-rubber coat, 3-wrench for opening the bottle, 4-spiral tube, 5-manometer, 6-tripod, 7-chlorine valve, 8-distributive tube reinforced, 9-extended tube, 10-slide valve, 11-hydrant tube, 12-exhaust extension.

The elements on the right half of the periodic table react with chlorine as well. Dry chlorine is much less reactive than the humid one. Completely dry chlorine, for example, does not bond with copper nor with iron, so it could be transported (in liquid form as well) in steel bottles under pressure of 7MPa. Chlorine is stored in liquid state only in chlorine reservoirs, which could be mobile or immobile. Mobile reservoirs are: bottles, barrels, tank wagon, road tanker and containers. Due to the fact that chlorine is very dangerous substance, special attention must be paid to the selection of the materials for the liquid chlorine containers. The material must be fully resistant to the chlorine corrosion. The containers are usually made of stainless steel. The facilities that store chlorine must maintain the temperature at the 40°C at the highest, and it is necessary to avoid direct contact with sunlight. The bottles for liquid chlorine are of various volume for 50, 75, 100, 150 and 200 kg. The bottle has safety cap, square nut, cap with bolt, seal and the valve. The quantity of gaseous chlorine that could be obtained in 24 hours from the 75 kg bottle is 20 kg. The reversed pressure of the discharging pipe is 3,5 MPa. Steel barrels for the liquid chlorine have the capacity to hold 500-1000 kg of chlorine. Tank wagon for chlorine have the capacity to hold 12-14 t of chlorine. Road tanker for liquid chlorine may hold up to 3000 ℓ of chlorine. Containers have the capacity to hold 5 t (as stationary reservoirs) while they are not in motion, but they do have cargo handles and could be used for transport.

For discharging of iron barrels, flexible copper pipes are used. They can endure pressure to 35 MPa and they are attached to the fixed pipes. The reaction is reversible and when heated at 450°C, calcium hydroxide turns into oxide. Calcium hydroxide is a very strong alkali and due
to the economical way of obtaining, it is commonly used in chemical industry. Solid Ca (OH)₂ and its water suspension absorbs CO₂ from the air creating CaCO₃:

$$\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$$

This reaction is the basis of the appliance of calcium hydroxide in construction. Calcium hydroxide can be used for chemical and biological decontamination of leather, metal, wooden, plastic, ceramic and other surfaces of structures and soil. For chemical decontamination, milk of lime is used after it is taken from one part of pickling lime which is distilled in three parts of water. It is used for decontamination of soil contaminated with poison gases and biological agents. In biological decontamination, milk of lime is used for decontamination of floors made of earth, brick, asphalt, stone and concrete, of walls, carts, motor vehicles, railway cars and others.

3. RESULTS AND DISCUSSION

Mathematical calculus brings to conclusion that the obtained solution of calcium – hypochlorite (which contains 4,76% of volume active chlorine) fully fulfills the demands of use for chemical decontamination. During the process of chlorine introduction all safety measures at work must be taken and as protective masks (instead of standard ones), special protective filters for chlorine are used. The introduction of chlorine lasts for approximately one hour, and the time period required depends on the initial temperature of the solution, air temperature, engine work of MDV, etc. The space where process of obtaining calcium hypochlorite is to be performed, security must provided. The process of chlorine introduction lasts approximately 60 minutes which depends on the capacity of reservoir, mixing velocity engine work, season and the looseness of valve for chlorine dosing. If the external temperature exchange is put aside, as well as certain heating of solution in MDV, the heightening of temperature (aside from rotameter, manometer, the extent of freezing chlorine bottle, measurement of bottle mass during chlorine introduction) may be an indicator of process and the finalization of process of chlorine introduction – introduction of gaseous chlorine into solution of hydrated lime. According to the thermodynamic equation for each percent of active chlorine, there is an adequate temperature rise of new solution for 3,9°C. When the temperature of solution rises for 10-12°C (it is measured after 60 minutes of chlorine introduction) then the introduction of chlorine into a cistern is stopped, and the difference in temperature is the proof that the appropriate solution of calcium hypochlorite has been obtained and that it could be used for chemical decontamination. After the procedure the chlorine bottle is closed, the pump and the mixer in MDV are turned off and then the sample should be taken (Erlenmeyer flask of 200 ml is plunged into the solution) for laboratory testing for the percentage of active chlorine in obtained solution. Basic parameters for obtaining the solution of calcium hypochlorite solution during the experiment (in experiments 1-6) are presented in table 1.

Table 1. The regime of obtaining calcium hypochlorite

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>Ca(OH)₂ (kg)</th>
<th>Reservoir (l)</th>
<th>Temperature (°C)</th>
<th>Chlorine introduction period (min)</th>
<th>% chlorine in solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>initial</td>
<td>final</td>
<td>t</td>
</tr>
<tr>
<td>1</td>
<td>33</td>
<td>500</td>
<td>15</td>
<td>27</td>
<td>12</td>
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<td>66</td>
<td>1000</td>
<td>16</td>
<td>26,5</td>
<td>10,5</td>
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<tr>
<td>3</td>
<td>66</td>
<td>1500</td>
<td>16,5</td>
<td>27,5</td>
<td>11</td>
</tr>
<tr>
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<td>99</td>
<td>2000</td>
<td>17,5</td>
<td>27,5</td>
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<tr>
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<td>165</td>
<td>2400</td>
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<td>29</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>170</td>
<td>2200</td>
<td>14</td>
<td>25,5</td>
<td>11,5</td>
</tr>
</tbody>
</table>
The results, which are obtained by introduction of chlorine in experiment, are approximately the same so they could be approximated to one introduction. The initial temperature of solution (suspension) of calcium hydroxide was 14°C, and afterwards it was measured in 10 minutes periods. In situations when there are no mobile decontamination vehicles (MDV), other vehicles with reservoirs can be used (preferably with a water pump and mixer due to effective chlorine introduction). The price of materials is 10 times lesser than the price of formed calcium hypochlorite in the world market. The obtained solution is stable enough so it could be kept for several days in closed reservoirs at room temperature, and when used in the process of decontamination new mixing will be required.

4. CONCLUSION

The basic indicator evaluation of the reactive ability of any system for decontamination is its efficiency which may be based on the quantity of the decontamination substance which is necessary for successful decontamination of certain quantity of chemical contaminant per unit of time. Chemical decontamination of people, materials and technology, clothes and equipment, soil and structures, food and water is achieved using complex physical and chemical methods (removal, absorption, adsorption, chemisorptions, oxidation, hydrolysis, chlorine introduction, alcoholysis and others) and chemical reactions may be carried out via various mechanisms. Mere awareness of the mechanisms of decontamination (for some reactions) is not sufficient for the efficiency evaluation, because the concordance with the test data is limited on the certain conditions. In practical experiments, teaching and exercises performing, for determining the effectiveness (how successful it is) of decontamination exact and less exact methods were used, and the results (summary) obtained were not sufficiently reproducible. A comparative laboratory method for testing the effectiveness level of the decontamination of means and structures contaminated with highly toxic substances is presented in this part of the study.

REFERENCES


