APPLICATION OF CALCIUM HYDROXIDE IN DECONTAMINATION OF CHEMICAL INCIDENTS

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Abstract: *Calcium hydroxide is an inorganic compound used for many purposes. Calcium hydroxide is relatively soluble in water. It partially dissolves in water to produce a solution called limewater, which is a moderate base. Limewater or aq.* $Ca(OH)_2$ *reacts with acids to form salts. As the calcium hydroxide is easy accessible, cheap and has the possibility to neutralize inorganic acids can be successfully used in their decontamination. This paper presents analyzes the decontaminating properties of calcium hydroxide.*

KEYWORDS: DECONTAMINATION, *CALCIUM HYDROXIDE*

1. Introduction

Large quantities of chemicals are also stored/ processed in industries that are located in densely populated areas. Inappropriate and haphazard construction and the spill of awareness and preparedness on the part of the community further enhance their vulnerability. The potential of heavy losses and adverse consequences on the environment due to a chemical accident calls for further improvement of safety measures in all processes/procedures and the adoption of appropriate methods for handling toxic industrial chemicals. An industrial accident is a sudden technological breakdown of machinery, equipment and aggregates, accompanied by stopping or seriously disrupting the process, building demolitions, fires, environmental pollution, destruction, sacrifice or life threats; the health of the population.

In the chemical industry, poisoning accidents lead to human injury and destruction of machinery and equipment. These industrial accidents are often accompanied by explosions of enormous destructive power and fires leading to large material losses and air pollution of entire areas with industrial poisonous substances.

Inorganic acids and bases are often transported and stored industrial materials which used in our industry. They are substances that cause burns when they fall on the skin of a human and also a source of poisonous gases. The more frequent and dangerous accident occurs when transporting acids because they are in a liquid state. In the history of our country, the last accidents of rail transport are spill acids are at Smyadovo Station (2015), place next to Kaspichan (2009). Rapid action taken to eradicate consequences of an acid leakage would lead to less damage to the people and the environment.

2. Decontamination of Acids

The action after acid spill, neutralization is surely one of the most significant, since it allows buffering the acid spill to a pH which is not environmentally-threatening.

The purpose of the article is to justify an effective and cheap decontaminant in the disposal of inorganic acids and a way of calculating its concentration.

Neutralization of acidic waste streams involves raising the pH, usually by adding an alkaline chemical, such as lime. There are several other chemicals that can also be used, but due to cost, handling problems, high total dissolved solids in the effluent, or mobility of heavy metals in the sludge, lime is the neutralizing material of choice. As highlighted in [4-6], when considering the cost of neutralizing agents and alkali requirements, lime is the most cost-effective option to neutralize acids. Factors to consider when choosing a neutralizing material include the cost of the material, the amount of sludge produced, the handling characteristics of the sludge, and the resulting quality of the effluent. Lime is most economical, but also offers other advantages. Lime is the neutralizing agent of choice in almost all applications. Lime sludge's are heavy, low volume, easy to handle, and easy to clarify. Most metals contained in the sludge are insoluble and will not readily leach into the environment. Finally, lime is the low cost reagent in terms of neutralizing value. [5, 7]

Calcium hydroxide is relatively soluble in water. It partially dissolves in water to produce a solution called limewater, which is a moderate base. Limewater or aq. $Ca(OH)_2$ reacts with acids to form salts, and it can attack some metals such as aluminum. Limewater readily reacts with carbon dioxide to form calcium carbonate, a useful process called carbonatation:

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

$Ca(OH)_2$ may use to decontamination to inorganic acids such as:

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

$H_2SO_4 + Ca(OH)_2 = CaSO_4 + H_2O$

$Ca(OH)_2 + HNO_3 = Ca(NO_3)_2 + H_2O$

In the case of accidents with toxic industrial chemicals, we have limited time to estimate the appropriate decontaminant and its concentration. When there is a chemical incident involving a spill of inorganic acid when transporting, the rules it must be a plate with a type of substance and its concentration and quantity. The same applies to toxic materials that we are stored. In order to achieve economics with the use of a decontaminant including calcium hydroxide, we can use Henderson-Hasselbalch equation. The Henderson-Hasselbalch equation relates pH, pKa, and molar concentration (concentration in units of moles per liter).

The Henderson-Hasselbalch approximation allows us one method to approximate the pH of a buffer solution. The basic equation is as follows:

(1) $$pH \approx pK_a + \log_{10}\frac{[A^-]}{[HA]}$$

Where: Ka is the dissociation constant of the weak acid, pKa=logKa, and [HA] and [A] are the molarities of the weak acid and its conjugate base.

The Henderson–Hasselbalch equation is, of course, the mass action expression cast in logarithmic format, and rescue teams have wondered if the thought of taking the logarithm of both sides of an expression should warrant immortalization of these two scientists.[3]

For a weak acid HA and its conjugate base A^-:

(2) $$HA + H_2O \leftrightharpoons H^+ + A^-$$

which has an acid ionization constant Ka. The Henderson-Hasselbalch approximation is derived from this acid ionization constant. [8]

(3) $$K_a = \frac{[H^+][A^-]}{[HA]}$$

(4) $$-\log_{10} K_a = -\log_{10} \frac{[H^+][A^-]}{[HA]}$$

(5) $$pK_a = pH - \log_{10} \frac{[A^-]}{[HA]}$$

(6) $$pH = pK_a + \log_{10} \frac{[A^-]}{[HA]}$$

Equation (6) is formulated in terms of equilibrium concentrations in solution. Since HA is a weak acid and weakly dissociates and we can introduce two approximations:

(7) $[HA] \approx [HA]_i$ and $[A^-] \approx [A^-]_i$.[8]

The Henderson–Hasselbalch equation may use in the same an base ionization constant Kb. Kb and Ka are table coefficients from chemical books.

3. Conclusion

In the case of chemical incidents involving spillage of inorganic acids, it is appropriate to use calcium hydroxide. The report is grounded in its use as a cheap and readily available reagent. In the decontamination of inorganic acids of which we know the species and concentration, we can calculate the concentration of calcium hydroxide by using Henderson-Hasselbalch equation.

4. Bibliography

1. Fusi L., Monti A., Primicerio M., Determining calcium carbonate neutralization kinetics from experimental laboratory data, J. Math. Chem. pg. 2492-2511. 2012.

2. Fusi L., Monti A., Farina A., Primicerio M., Mathematical Model for Calcium Carbonate Acid Mine Drainage Reaction: a Multiple Time Scale Approach, Rend. Lincei Mat. pg. 1-24. 2013.

3. Grisham, Charles. Biochemistry: Updated Third Edition. Belmont, Ca; Thomas Learning Inc. 2007. pg. 37-40.

4. Hairston, D., Acid Neutralizers. Calm the Wastewaters. Chemical Engineering. 1996.

5. Acid Neutralization with Lime. National Lime Association, Bulletin No. 216. 1995.

6. Teringo, J.,Comparing Acid Waste Stream Neutralization Methods. Plant Engineering. 1990.

7. www.lime.org

8. Henry N., Senozan N., Henderson-Hasselbalch Equation: Its History and Limitations, J. Chem. Educ., 2001.