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Use of Controlled Slow-Release Encapsulated Substrates to Enhance In Situ Reductive Dechlorination Processes

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Background/Objectives. Organic and carbonyl salts have been effectively used as organic hydrogen donors during anaerobic dechlorination processes. Specifically, calcium propionate has been found to be more effective than other electron donors that produce hydrogen necessary for dehalogenation, such as formate, ethanol, or glucose. The reason is that various groups of microorganisms compete for hydrogen, and that dehalogenating microorganisms can survive better than others at very low hydrogen concentrations. On this basis, slug addition of a compound such as formate, ethanol, or glucose is not as effective for dehalogenation as propionate, because the former compounds are converted rapidly to hydrogen and acetate, and the latter is not. The rapid conversion is a result of more favorable thermodynamics with respect to hydrogen formation. Such rapid conversion places hydrogen in a concentration range where methanogens and sulfate reducers can compete effectively with dehalogenators.

Approach/Activities. This study provides an alternative method to control the release rate of the organic hydrogen donors in the solution during reductive dechlorination remedial processes. The newly introduced organic substrates are encapsulated and have the potential to control the release of the organic hydrogen donors in the solution. Experimental results are presented below that demonstrate a significant difference in the release rate of calcium ions from the organic hydrogen donor calcium propionate in the solution. Also, as an added benefit, supplemental materials can be added to the process to assist in controlling the pH level of the targeted system. Such materials include, but are not limited to, hydroxides, carbonates, and zero valent metals.

The experimental procedures presented in this study were performed using encapsulated calcium propionate 80% in a distilled monoglyceride matrix. The results of the encapsulated material were compared with those of regular calcium propionate. Monoglycerides are among the most promising polar lipid compounds able to bring new or improved functionality to food products since they form self-assembly structures in both lipid and aqueous phases.

Results/Lessons Learned. Two different dosages (0.5 g/L and 1 g/L) of both the regular calcium propionate (RCP) and the encapsulated 80% calcium propionate (ECP) were tested to compare the calcium release rates of both materials. As the results show, ECP showed much slower release rates upon the completion of the 14-day experimental procedure.

In fact the 0.5 g/L ECP did not show any release of calcium during the first 2 days of the mixing procedure, while the release was increased to 5.8% of total calcium content 14 days upon the start of the experiment. Similarly the 1 g/L ECP showed a 2-day calcium release of 11.7%, which increased to 17.5% during the 14-day sampling period. Conversely RCP showed much higher calcium release rates in the solution. For the 0.5 g/L RCP the amount of calcium released was at 37.4% after 2 days of mixing and 56.1% after 14 days. For the 1 g/L RCP calcium release was at 56.1% after 2 days and at 65.4% after 14 days.

In addition to the data presented for the encapsulated organic hydrogen donors, similar research showed that lipid encapsulated iron was effectively used to provide an alternative way for a slower and controlled release of the iron into the solution.