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Effect of commonly found organic acids in food industry for the degradation of cementitious materials

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Even though stainless-steel surfaces are considered to be the most preferred contact surfaces used in the food industry, cementitious surfaces are still used in local industries. In this study, we have focused on three different carboxylic acids, which are common by products of the food industry including citric acid, malic acid and acetic acid to evaluate their impact on cementitious materials. During the study, we used different concentrations such as 1 M citric acid, 1 M malic acid and 10 M acetic acid to treat with previously weighed small cement strips (2.5 cm × 2.5 cm × 0.4 mm) for one hour and the treated strips were analyzed with PXRD and FT-IR. These concentrations were selected due to the quick response and thereby to evaluate the aggressiveness of acids towards the cement matrix. According to visual observations, after one hour of dipped time, 1 M citric acid and 1 M malic acid have shown weight loss percentages of 15.05% and 15.24%, respectively while the cement strips dipped in 10 M acetic acid have shown complete dissolution. Powder X-ray diffraction (PXRD) results were taken for sand, ordinary portland cement (OPC), hydrated cement and for citric acid treated cement strip. FT-IR spectroscopic data were obtained for three different acid solutions and for treated cement strips, sand, OPC and hydrated cement. According to PXRD results, OPC has shown 2-theta values corresponding to hatrurite, calcium silicon aluminum sulfur, aluminum sulfide, and aluminum oxide. In contrast, hydrated cement has shown compounds including gypsum, alpha SiO₂, calcite, calcio-olivine, calcium silicate hydrate and calcium silicate. The 2-theta values for 1 M citric acid treated cement strips have shown silicalite, silicon dioxide, magnesium oxide, and calcite. FT-IR spectroscopic data have depicted different characteristic peaks corresponding to acid treated cement strips in comparison with hydrated cement. Hydrated cement has shown an IR peak at 1004 cm^{-1} which is relevant for the calcium silicate hydrate bond (C-S-H). Acid treated cement strips have shown characteristic peaks for the COO⁻ group in the wavenumber range of $1538\text{-}1580\text{ cm}^{-1}$. It can be concluded that different carboxylic acids have an impact on the crystal phases as well as the bond structures of hydrated cement.

Keywords: Carboxylic acids, cementitious material, calcium silicate hydrate bond

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