

Abstract

To prevent the degradation of historical materials under the influence of external factors, a variety of conservation treatments are employed, one of them is consolidation. For the effective consolidation of the original material, the consolidants must have a variety of desirable properties, such as: the ability to establish adhesion between particles of deteriorated historical material, compatibility with the material, deep penetration into the substrate, a broad temperature range during application, the porosity and appearance after consolidation should be maintained, and they must be environmentally friendly. Currently, the most commonly used consolidants for the consolidation of carbonate-based substrates are based on nanoparticles suspended in different alcohols. The disadvantages of these consolidants are the small penetration depth, the limited solubility and the formation of a white haze after application. For the consolidation of mineral materials a new method was proposed – consolidation with an aqueous solution of calcium acetoacetate, $\text{Ca}(\text{OAcAc})_2$. This material has not yet been proposed for this purpose; therefore, its properties and the mechanism of its action are completely unknown. $\text{Ca}(\text{OAcAc})_2$ in the presence of water decomposes to acetone, CO_2 and CaCO_3 . Consolidation is achieved when the CO_2 and acetone evaporate and the solid CaCO_3 remains, which works as the binder. The main objective of the doctoral dissertation was (i) to determine the mechanism of consolidation, (ii) to investigate different influences, such as the temperature, relative humidity, amount of $\text{Ca}(\text{OAcAc})_2$ in solution, pH value, hydrodynamic conditions and the addition of various catalysts and other additives, on the rate of reaction and (iii) to determine the effectiveness of the consolidation on selected mineral surfaces. Systematically, the rate of decomposition of $\text{Ca}(\text{OAcAc})_2$, the mechanism of formation of CaCO_3 and transformations thereof into different crystalline forms under various conditions have been studied. Two systems have been examined: $\text{Ca}(\text{OAcAc})_2$ under an air atmosphere and $\text{Ca}(\text{OAcAc})_2$ dissolved in water. It was found that $\text{Ca}(\text{OAcAc})_2$ decomposes much faster in an aqueous solution than in air, even when exposed to high humidity (98 %). CaCO_3 particles formed in the air are connected in spherical aggregates, while in an aqueous solution they form a lamella structure. In both systems the resulting crystal form was vaterite, which forms more slowly in lower humidities. Only when the pH value of the aqueous solution was high (pH = 12), the formed CaCO_3 was calcite. The addition of catalysts accelerate the decomposition of $\text{Ca}(\text{OAcAc})_2$ only when exposed to a lower humidity (33 %) and in the initial exposure times; however, in a water solution they have no influence. From selected catalysts the most effective were diaminoethane, diethylenetriamine and glycine. Higher temperatures accelerate the decomposition of $\text{Ca}(\text{OAcAc})_2$ in an aqueous solution, but have no effect on the resulting phase of CaCO_3 , which is vaterite. The concentration of $\text{Ca}(\text{OAcAc})_2$ in an aqueous solution and the hydrodynamic conditions determine the morphology of the formed aggregates of vaterite. Moreover, the consolidant efficiency was studied on two laboratory-prepared substrates: gypsum and CaCO_3 paste. It was found that the solution penetrates through the entire section of the substrate, where an increase in the strength was obtained. However, the strength decreased with time exposed to the conditions. The presence of $\text{Ca}(\text{OH})_2$ in the CaCO_3 paste has a strong influence on the resulting crystal form, which was detected as calcite and/or aragonite. After consolidation, the porosity and permeability to water vapor of the substrates decreased; however, after time it returned to approximately the same values as those of the non-treated substrate. Consolidation with $\text{Ca}(\text{OAcAc})_2$ does not change the color of the substrate. On two *in-situ* studies the consolidant efficiencies of $\text{Ca}(\text{OAcAc})_2$ and the commercial consolidants CaLoSiL, Nanorestore and Nano-lime RC were tested. The best recovery in terms of mechanical properties and without changing the appearance of the wall painting was achieved after the treatment with $\text{Ca}(\text{OAcAc})_2$, while commercial consolidants consolidated mostly on the surface of the wall painting, which may result in the formation of a white haze on the surface after consolidation.