

Control of binder viscosity and hygroscopicity on particle aggregation efficiency

Sebastian B. Mueller (), Ulrich Kueppers (1), Paul M. Ayris (1), Michael Jacob (2), Pierre Delmelle (3), and Donald B. Dingwell (1)

(1) Ludwig-Maximilians-Universität München (LMU), Earth and Environmental Sciences, Munich, Germany, (2) Glatt Ingenieurtechnik GmbH, Verfahrenstechnik, Weimar, Germany, (3) Université catholique de Louvain, Earth and Life Institute, Louvain-la-Neuve, Belgium

In the course of explosive volcanic eruptions, large amounts of ash are released into the atmosphere and may subsequently pose a threat to infrastructure, such as aviation industry. Ash plume forecasting is therefore a crucial tool for volcanic hazard mitigation but may be significantly affected by aggregation, altering the aerodynamic properties of particles. Models struggle with the implementation of aggregation since external conditions promoting aggregation have not been completely understood; in a previous study we have shown the rapid generation of ash aggregates through liquid bonding via the use of fluidization bed technology and further defined humidity and temperature ranges necessary to trigger aggregation. Salt (NaCl) was required for the recovery of stable aggregates, acting as a cementation agent and granting aggregate cohesion. A numerical model was used to explain the physics behind particle aggregation mechanisms and further predicted a dependency of aggregation efficiency on liquid binder viscosity.

In this study we proof the effect of viscosity on particle aggregation. HCl and H₂SO₄ solutions were diluted to various concentrations resulting in viscosities between 1 and 2 mPas. Phonolitic and rhyolitic ash samples as well as soda-lime glass beads (serving as analogue material) were fluidized in the ProCell Lab[®] of Glatt Ingenieurtechnik GmbH and treated with the acids via a bottom-spray technique. Chemically driven interaction between acid liquids and surfaces of the three used materials led to crystal precipitation. Salt crystals (e.g. NaCl) have been confirmed through scanning electron microscopy (SEM) and leachate analysis.

Both volcanic ash samples as well as the glass beads showed a clear dependency of aggregation efficiency on viscosity of the sprayed HCl solution. Spraying H₂SO₄ provoked a collapse of the fluidized bed and no aggregation has been observed. This is accounted by the high hygroscopicity of H₂SO₄. Dissolving CaCl₂ (known to be a highly hygroscopic salt) in de-ionized water yielded comparable results without observable aggregation. In case of successful aggregation, concentration of salts has been found to be in the range of published values. We conclude that non-hygroscopic salt crystal precipitation from an aqueous liquid interacting with the glass phase in volcanic ash is a very efficient way to produce cohesive ash aggregates that can survive external forces acting during transport and sedimentation.