IMPORTANCE OF GAS LIQUID PARTITIONING COEFFICIENTS IN CHEMICAL SCRUBBERS: A CASE STUDY FOR AMMONIUM SULPHATE AND SWINE DUST

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Chemical air scrubbers are implemented in livestock production facilities to treat waste gas containing ammonia. During the operation of an acid (H2SO4) scrubber, ammonia is absorbed and dust particles are trapped in the scrubbing liquid. Therefore, the properties of the washing liquid are changing continuously. The reaction of ammonia and sulphate (acid scrubbers, based on sulphuric acid) increases the ammonium sulphate (AS) concentration. Also, absorbed particles can change the organic content of the scrubber liquid. These factors can have an influence on the gas liquid partitioning coefficient (K_{AW}, air to water) of odorous compounds, present in livestock waste air. The higher K_{AW}, the more difficult it is to absorb odorous compounds in the scrubber liquid resulting in lower removal efficiencies and higher emissions.

The aim of this study is to determine the air water partitioning coefficients of 5 important odorous compounds: dimethyl sulphide (DMS), dimethyl disulphide (DMDS), hexanal (HEX), 2-methylpropanal (2-MP) and 3-methylbutanal (3-MB), in function of the ammonium sulphate concentration (0-300 gL^{-1}) and dust concentrations (0-2 g^{-1}). Particulate matter used in this study was collected at a swine stable at ILVO (Belgium). Also the temperature influence on the K_{AW} was investigated (4-25 °C). Next to the laboratory controlled liquids, also chemical scrubber liquid samples were evaluated and the K_{AW} was determined for the target compounds.

All gas liquid partitioning coefficients where measured with a newly developed dynamic absorption technique (DynAb method) using SIFT-MS (Selected Ion Flow Tube Mass Spectrometry) as measuring tool. Briefly, a pure nitrogen air stream is bubbled through liquid with known properties (Salt, Particle concentration). At time zero, the pure air stream is switched to a contaminated air stream with a constant concentration of odorous compounds. From that time, the odorous compounds starts to absorb in the liquid until there is an equilibrium between the liquid and the contaminated air stream. The outlet concentration is continuously monitored by SIFT-MS and results into a breakthrough curve. The area above this breakthrough curve is related to the absorbed mass in the liquid. The partitioning coefficient can be calculated if the liquid volume and air concentration are known.

When the temperature increases from 4 to 25°C, the K_{AW} increases with a factor 5. Raising the AS concentration (0 to 300 g L^{-1}), increases the K_{AW} with a factor of 10 (25°C). This implies that lower removal efficiencies will be obtained in scrubbers operating with high AS concentrations in the scrubbing liquid, due to a lower mass transfer. Practical samples (from an operational scrubber) showed even a slightly higher K_{AW} when compared with pure (aq distilled) ammonium sulphate solutions. In the concentration range of 0-2 g L^{-1} (25 °C) particulate matter, the K_{AW} was not significantly different in comparison to pure water. The organic content in scrubber liquids is likely too low to decrease the K_{AW} value. Also salts, present in the particulate matter, might increase the K_{AW}. The results prove that the determination of K_{AW} values of odorous compounds is important for scrubber reactor design in the field of livestock and bio-waste valorisation applications.