# Humidity Mass Transfer Analysis in Packed Powder Detergents

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## Abstract

Powder detergents containing sodium percarbonate and bleach activators undergo chemical decomposition when exposed to high relative humidity. Controlling the moisture intake in finished product packs is therefore a fundamental need in order to guarantee product stability during the whole supply chain. In this paper we show how we have leveraged COMSOL Multiphysics capability in order to model the complex mechanism of moisture migration and absorption in powder detergents; water vapor coming from high relative humidity external environment migrates through the package barrier, and eventually is absorbed by the powder, which has a non-linear absorption property in function of the surrounding relative humidity. The underlying physics is that of a mass transfer through diffusion, in presence of two phases: bound water in the powder and mobile water in vapor phase. The two phases are exchanging moisture and, in general are not at thermodynamical equilibrium characterized by the non-linear vapor sorption curve of the product. The driving force behind moisture diffusion is the overall chemical potential (water activity) gradient, rather than moisture concentration, thus we are not solving a pure fickian diffusion problem. The moisture sorption and thus the moisture diffusivity is a non linear function of moisture activity and so is the sorption kinetics from mobile to the steady phase. This model is achieved by coupling two non steady state mass conservation physics. We have used this model to design and optimize the product properties and package characteristics in order to guarantee sufficient moisture control throughout the whole supply chain. In a parallel work we are developing a kinetic model that analyzes the chemical degradation of our main chemical species in function of temperature and ambient humidity. By coupling the 2 models we have a realistic prediction of product chemical stability throughout the supply chain.