Effect of carbon black selection on semiconductive compound water content and uptake behavior

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Water molecules entrapped in HV and EHV cable insulation are known to promote electrical treeing. As HV and EHV cables are usually protected from external water penetration, the main source of water molecules inside a cable is certainly the insulation compound used during cable manufacturing but also the water contained in both conductor and insulation shields that can migrate into the insulation layer during cable operation and contribute to electrical degradation. It should be remarked that water can have also a solvation effect on the ionic species present in the carbon black, for example, transition metal ions or organic ionic species, which can migrate as well in the insulation layer are known to catalyze polymer degradation.

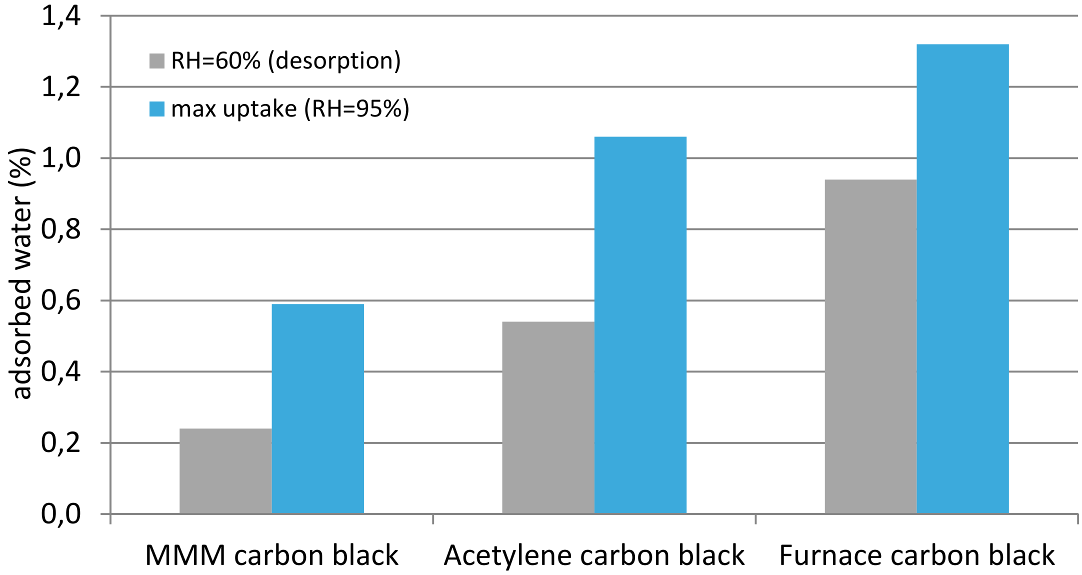

Fig. 1: Water uptake of conductive carbon blacks in two different conditions by dynamic vapor sorption measurement.

Conductive carbon black is one of the main constituents of semicon formulations and has its own moisture content, normally specified in the carbon black technical data sheet. The water content level depends on many factors, first of all it is related to the production process and to how it is packed, then it is related to the specific type of carbon black produced, for example extra conductive carbon blacks are known to have a very high moisture uptake. In extra conductive carbon black moisture uptake is normally related to the very high specific surface area of this material but also carbon blacks with similar surface area can differ in water content. Surface chemistry certainly plays a role in the water uptake mechanism, for example the presence of oxygen groups promotes water uptake but also the porosity (microporosity and mesoporosity) of the material can influence moisture adsorption.

In this article we will compare the moisture uptake behavior and the ionic content of three different carbon blacks with similar surface area but produced with different production processes: furnace, acetylene and MMM processes. The moisture uptake behavior in different conditions will be analyzed (as packed, in ambient condition, after drying procedure, etc.) and correlated to specific characteristics of the carbon black (for example surface chemistry and porosity). Finally, the moisture content of the compounds made with the three different conductive carbon blacks will be analyzed and discussed in relation to cable manufacturing.