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SURFACE PROPERTIES OF METAL OXIDES – FROM MACRO- TO NANO-SCALE

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INTRODUCTION: Metal oxide surfaces are the most common supports in technical applications. Occasionally, they can be coated with several substances having abilities to self-assemble[1], to modify or to improve their capabilities. Especially, corrosion inhibition, adhesion promotion or protein resistance are of huge interest for further coatings. Special adhesion promoters are necessary to apply known systems of appropriate polymers on important metal oxide surfaces like aluminum, tantalum or titanium oxide. Therefore, different bifunctional alkyl phosphonic acid derivatives have been designed and synthesized.

METHODS: Freshly prepared metal oxide surfaces are immediately covered by organic residues from the atmosphere. For that reason they must be cleaned carefully, e.g., by ultrasonification before adsorption. Several chemically and physically induced surface pretreatment methods have been used, including oxygen plasma treatment, wet chemical staining and etching. Detailed information of the chemical and physical properties of the used metal oxides are necessary to improve the properties of the substances as well as the procedures by applying adhesion promoters.

We use several surface sensitive methods of different resolution capabilities to obtain this information. Contact angle measurements and microdroplet analysis were used to obtain macro-scale information (mm to µm) about the treated surfaces. Microdroplet analysis bases on characteristics of condensation of vapors on cooled surfaces[2]. Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) with EDX are the methods to get structural and chemical information about surfaces in the nano-scale (µm to nm). X-ray Photoelectron Spectroscopy (XPS) and angle-resolved XPS give information about the atomic composition of the metal oxides and adsorbed layers as well as the orientation of the adsorbed molecules.

Surface plasmon resonance spectroscopy (SPR)[3] is used to follow kinetics during the adsorption processes of different surface active molecules on alumina substrates. For SPR special substrates[4] are necessary e. g., consisting of BK7 glass, 45nm Au and 2.5nm Al_2O_3.

RESULTS: Contact angle and SPR- measurements revealed that phosphonic acid derivatives adsorb readily and spontaneously onto alumina. The intermolecular organization and ordering processes of these self-assembled layers require more time (see figure 1, 60-1200 min). Angle-resolved XPS of bifunctional phosphonic acids revealed ordered layers where the phosphorus is attached to the substrate surface and the functional moiety faces away from it.

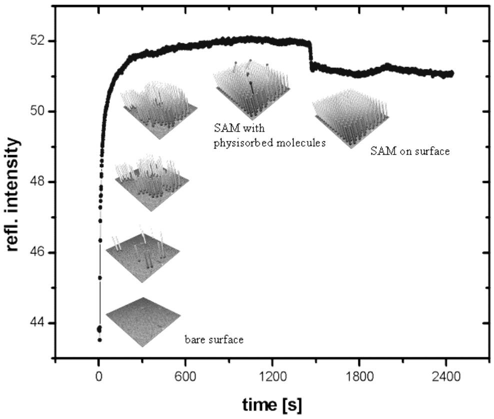

Fig. 1: Typical SPR measurement in kinetic mode.

DISCUSSION & CONCLUSIONS: Several surface-sensitive methods were used to characterize different metal oxide surfaces. SPR is able to resolve kinetic processes on alumina surfaces. Contact angle measurements give first indication about successful treatment as well as adsorption. Microdroplet analysis reveals disordered areas on the surface in the range of some µm. Surface coverage and molecular order normal to the surface can be concluded from XPS results. AFM and SEM show characteristics of surface morphologies. Kind of material and pretreatment have a great influence on the self-assembly monolayers resulting from adsorption.

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