Scratch-proof Coating of Wood and Plastics Based on Silica-modified, Aqueous Polyurethane Dispersions

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Introduction

Aqueous lacquers are based on polymeric dispersions of fine, 50-200-nm-large particles, which are set in such a way that they, as soon as the water evaporates, merge to form a homogeneous film, also at low temperatures. Such lacquer films are vulnerable to scratching, especially to micro scratching. One issue in the project was whether such susceptibility could be reduced by adding hard, inorganic nanoparticles. Simply mixing nanoparticles into aqueous lacquers lets them aggregate, and compounding of the inorganic nanoparticles with the organic phase of the bonding agent does not occur. In order to avoid that, the nano particles must be built directly into the dispersed polymeric particles. This was expected to be successful with aqueous polyurethane dispersions (PUD), which increasingly supersede the previously common acrylate dispersions.

A second issue was how to differentiate evaluations of micro scratch resistance, as the previously established micro scratching procedure acc. to EN 16094 was incapable of doing so.

Objective

The goal of the project was to develop novel, polyurethane-based aqueous lacquers (physically drying, two-component and UV-curing) for indoor applications of wood and plastics with significantly improved micro scratch resistance. The improvement was to be achieved by permanent incorporation of silica-nanoparticles in the lacquer polymer. These works were carried out by the project partners LBF and ILF. The development of a differentiating micro scratch test procedure was the task to be done by the IHD. The following refers to this second part of the task exclusively.

Material and Method

The methodical testing investigations were carried out on ten different aqueous lacquering systems, which were examined as they were, and also modified by aerosoles.

The Martindale unit, which generates large-size Lissajous movements on samples measuring 150 mm by 150 mm, served as the test device. Several scratching materials were examined for their fitness to serve differentiation. Contact pressure and the cycle count were to be determined in such a way that scratching occurred and no significant abrasion or polishing took place. For evaluation, a change in gloss (reduced by micro scratches; procedure A) and visual judgment of existing traces of scratching, evaluated by a descriptive numerical code (procedure B) were determined as parameters. After investigation concerning differentiability and repeatability, the test parameters were defined in an IHD works standard draft, IHD-W-474. The test procedure was validated and optimised in comparable tests performed with the project partner ILF, further involving three more lacquering systems for plastics.

Development of Test Procedures for the Faster Prognosis of Long-term Preservation of Outdoor Wood Coating

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Objective and Approach

It was the objective of the project to investigate various already established, but also novel chemical and physicoanalytical procedures and methods for characterising and testing surfaces, for their predictive reliability regarding the long-term and protection behaviour of outdoor wood coating. Apart from the classical surface test methods to determine changes to the degree of gloss or colour, adhesion and water and vapour permeability, this is also about microscopic (light microscopy, REM, Raman microscopy) and micromechanical procedures (determination of micro hardness), thermochemical analytical methods (DSC) and several spectroscopic (FTIR, Raman, UV/Vis, fluorescence spectroscopy) and chromatographic methods (GPC, GC/MS, Pyr-GC/MS, HS-SPME-GC/MS). A GC/MS system, combined with a micro UV lamp, was used as a completely novel analytical device (Fig. 1a), which served the identification of volatile photochemical degradation products (Fig. 1b) that are formed immediately after being irradiated by UV light. In the field of characterising various types of wood coating and their photochemical degradation, there is the novel method for determining ion permeability as well as the new chemiluminescence-based analysis (CL). There is hope, by applying them, to be able to make statements on the impact of structural pores and oxidiation resistance of bonding agents and additives on the weathering resistance of wood coating. Within the scope of the project, initially those procedures were expected to be worked out which, if possible during the early period of strain, indicate weather-dependent changes in the chemical structures and changes resulting from them in physicochemical and chemical properties. Also, the measurements and test results obtained were to be related to the protective behaviour of the coating, which was obtained from artificial and natural weathering tests.

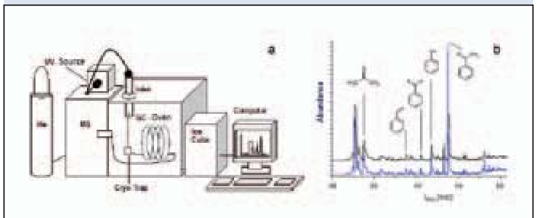

Fig. 1: a) Schematic setup of a GC/MS system connected to a micro UV xenon short-arc irradiator; b) chromatogram of slightly volatile photooxidative degradation products of a transparent styrene-acrylate-based lacquer film

Results

The following analytical methods have proven to be especially suitable to detect weather-related changes in the chemical structure of the coating materials in the early period of strain: 1) FTIR-ATR, 2) DSC, 3) UV-GC/MS, 4) HS-SPME-GC/MS and 5) the CL analysis. With their help, photochemcial degradation mechanisms as described in the literature could be reproduced, but also new insights with a view to 1) the chemicophysical degradation of wood coating and 2) the influence of several additives on changes of properties of the coating materials relating to that context, could be obtained. So it could be shown that weather-dependent