# 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.

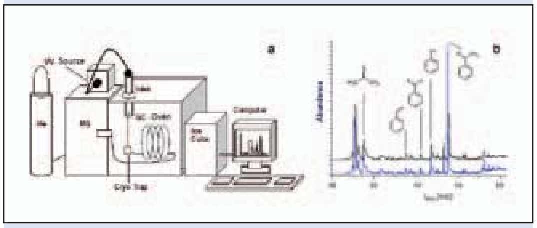

*Fig. 1: a) Schematic setup of a GC/MS system connected to a micro UV xenon short-arc irradiator; b) chromatogram of slightly volatile photooxidative degradation products of a transparent styrene-acrylate-based lacquer film*

**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 material changes are quite substantially caused by leaching, emission and photooxidative degradation of coalescence agents, (temporary) softeners and defoamers/deaerators. Furthermore, the photocatalytic effect of titanium dioxide, applied as a white pigment, could be verified, which was especially apparant when photosensitive bonding agent components (e.g., PS) or additives (e.g., PEG) were prevailing. What was also successful was the demonstration and development of relevant effects in dependence on weathering time, which allowed to make statements regarding respective trends of reaction and the sensitivity of coatings and their components towards photolytic and photooxidative degradation (Fig. 2).

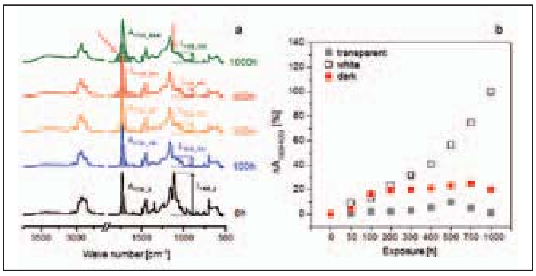


*Fig. 2: a) FTIR-ATR spectrums of a white-pigmented, styrene acrylic wood coating after several periods of weathering (0-1000 h); integrals and intensities of selected ranges are highlighted; b) changes in per cent of the peak integral of υ (C=O) styrene acrylic wood coating variously pigmented depending on the weathering duration*

Methods with the help of which weather-dependent and physical properties could immediately be detected, are measuring procedures to determine 1) the glass transition temperature, 2) micro hardness, 3) colour and 4) gloss.

By means of the temporal courses of these changes in properties during artificial and outdoor weathering, correlations with changes in chemical structures could be derived. Mathematical-statistical modelling was further able to establish significant interdependencies between 1) the lacquer recipe and protection behaviour, and 2) changes in physical properties during artificial weathering and protective behaviour (Fig. 3). Proceeding from that, it was possible, by applying procedures of multiple regression, to derive prognostic models which, by including recipe data, physical and physicochemical properties of unweathered referential coatings as well as changes in the properties during artificial weathering, allow to make orienting forecasts for macroscopic properties that are connected to the protection behaviour of wood coatings (Fig. 4). A transfer of these procedures into practice appears generally possible, it is, however, subject to result evaluation of previously uninvestigated coating systems.

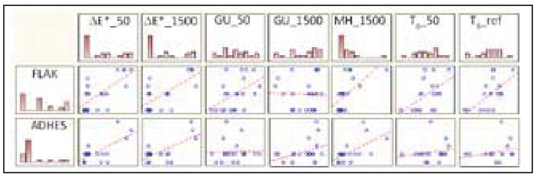


*Fig. 3: Extract from a spread graph matrix with correlations between selected macroscopic properties of wood coatings after 24 months of outdoor weather exposure (FLAK: degree of peeling, ADHES: adhesion) and physical properties of unweathered (Tg_ref) as well as 50/1500 h artificially weathered coatings (ΔE*: colour difference, GU: degree of gloss, MH: micro hardness, Tg: glass transition temperature)*

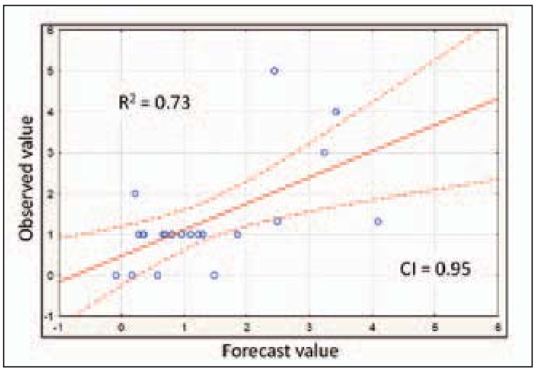


*Fig. 4: Predictive reliability of a linear, multiple regression approach to estimate adhesion properties acc. to ISO 2409 (long-term prognosis) based on the variables of pigmenting, colour distance ΔE*_50, micro hardness MH_1500, glass transition temperatures Tg_ref and Tg_50*