Sol-Gel Coating of Thermoflooring: Haptics and Performance of a new Surface Coating for Solid Wooden Flooring made of TMT

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ABSTRACT

Wooden floorings, like parquet or solid wooden, are more and more displaced by laminates due to lower prices and often more competitive mechanical performance. Major argument for wooden flooring is often the wish for natural material which will be felt by customer. To ensure natural haptics oils are widely used in coating these wooden floorings taking a loss in mechanical performance. This paper describes the results and development of a new surface coating using sol-gel technology for solid wooden flooring made of thermally modified timber (TMT). Different coatings have been developed and evaluated for industrial use. Curing is possible by either thermal or UV conditions. Performance criteria like abrasion, hardness, chemical and scratch resistance etc. as well as haptics have been evaluated and benchmarked with existing products on the market. Advantages in terms of performance and haptic will be presented, as well as results from real life tests on the prototypes installed at different locations in Europe.

INTRODUCTION

Basically there are two different classes commercially available for wooden floor coating. On the one hand film forming ones, usually on the basis of acrylate or urethane. Such coatings result in a film on top of the wood exhibiting high performance mechanical properties like abrasion resistance, scratch resistance etc. equally to laminates. On the other hand non-film forming wooden floor coatings like oils and waxes offer due to the absence of a film natural, but sometimes sticky feeling. Such haptic properties often wanted by the customer go along with clearly reduced mechanical performance in comparison to film forming coatings, but show a clear differentiation from laminates. Inorganic-organic hybrids based on sol-gel processes are well known for tailoring surface properties like surface energy, increase of hardness or chemical functional groups (Brinker and Scherer 1990). Surface modification and impregnation of wood using alkoxysilanes, either directly by hydrolysis with wood moisture or after hydrolysis as so called sols hydrolysed are reported in literature affecting durability, dimensional stability, fire retardancy or moisture sorption properties (Saka and Ueno 1997, Tsaballah *et al.* 2003, Mai and Militz 2004, Donath *et al.* 2004). Sol-gel derived coatings on thermally treated timber (TMT) have been reported in literature by Schöftner *et al.* 2003, Wang *et al.* 2008, Mahltig *et al.* 2008. In addition to the approaches of thin inorganic films, nanoparticles and inorganic building blocks within polymers (Kickelbick 2002) as well as the use of different hybrid classes can be applied for coatings design (Sanchez *et al.* 2003, 2005), also for wood coatings.

MATERIAL AND METHODS

Tetraethoxysilane (TEOS), Vinyltriethoxysilane, Alkylethoxysilanes, Metacrylmethoxy and Fluroalkytriethoxysilanes have been hydrolysed for 12 hours under acidic conditions using ethanol as solvent. After solvent removal the inorganic component is mixed with the organic components (vegetable oils) and catalyst is added prior to coating. Prior to use the non film forming coatings have been either UV-cured or thermally hardened.

Pencil hardness was determined using a Erichson Scratch Hardness Tester acc. to Wolff-Wilborn, Model 291 , Abrasion resistance has been determined using a Taber abraser (500 g, S33, n=100, weigth loss) on razor blade coated metal plates. Chemical resistance was measured according to EN 13442. The static contact angle of water was determined using a DSA100, Krüss. Also Black heel mar resistance was determined. Thermally treated wood species used have been ash in mezzo treatment, beech in forte treatment (Thermoholz Austria GmbH, Gaflenz, A). For flooring application, the corresponding wood materials with a thickness of 10.5 mm was profiled with a click-system (Valinge Innovation, AB) and sanded using a grain size of 120 prior to coating.

RESULTS AND DISCUSSION

Pure sol-gel systems have been optimized in terms of durable hydrophobicity by optimizing pre-cursor materials and their concentrations. Key factor was maximizing the penetration stability at high contact angles of water (>100°). Our optimized sol-gel coating retains the contact angle also after strongly rubbing the surface, in comparison to most published and commercial available systems. In addition the system offers excellent "Anfeuerung" of the wood – thermally treated as well as untreated. Nevertheless the mechanical properties like abrasion resistance have been not satisfactory at standard tests as well as in real use on prototypes. The problem identified, especially in terms of soiling tendency are the still open pores of the wooden material. Overcoming this problem a class II hybrid system with the ability to fill up the pores of the wood structure was chosen to overcome these drawbacks.

Such hybrids have been synthesized using sol-gel based nanobuilding blocks in acrylate, polyurethane (PU) and vegetable oil-based polymers. The evaluation of these three systems in terms of haptic properties showed the oil based hybrid system as favourite. Looking on abrasion resistance, determined on the wooden samples the addition of surface functionalised, fumed silica nano particles (np) to the hybrid systems could dramatically improve the performance by lowering the weight loss per 100 turns by 43% for oil hybrids, 52% for acryl hybrids and 50% for PU hybrids at a np concentration of 2.5%, while a doubling of the np concentration to 5% only led to a further reduction of about 7%.

Comparing the abrasion resistance of the oil-hybrid coating on razor blade coated metal plates with commercially available systems a clearly better performance could be shown (see Figure 1 - left). The pencil hardness of the hybrid coatings can be easily adjusted by the amount of inorganic sol-gel components as shown in Figure 1 – right.

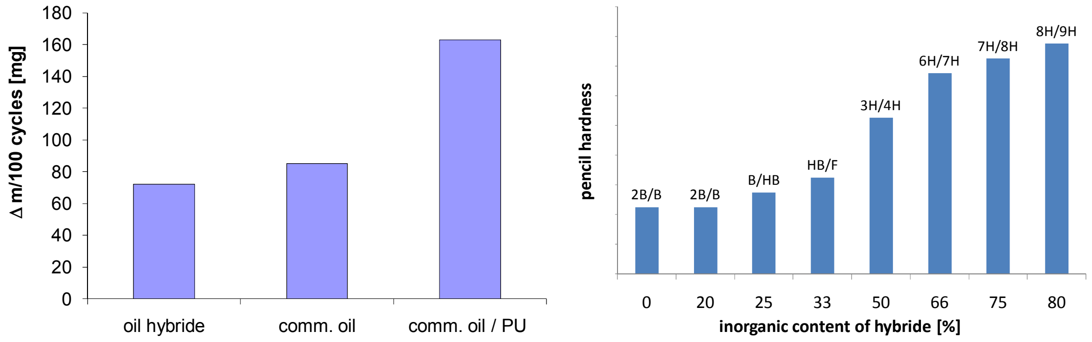

Figure 1: Mechanical performance tests of the developed hybride coatings. Left:Results from Taber abraser test (S33, 500g); Right: Pencil hardness of hybrids with different inorganic content.

Keeping the inorganic component constant within a given formulation, an increase of TEOS content within the inorganic hybrid part shows an increase of pencil hardness from 3H/4H at 15% TEOS to 5H/6H at 45% TEOS content. Results from chemical resistance testing as presented in table 1, show best performance for the acryl hybride system followed by the oil hybride. It should be mentioned, that a single application of oil hybride coating shows equivalent performance to douple applied commercial hard oil and commercial oil system, resulting in a saving of 50% material and time at equivalent performance.

Table 1: Results of chemical resistance testing

reagent	sol-gel[2]	hardoil[2]	comm. oil[2]	oil hybride[1]	oil hybride[2]	acryl hybride[1]
water	5	5	5	5	5	5
detergent	3	3	1	4	4	5
acetone	3	5	5	5	5	5
ethanol 50%	4	5	5	5	5	5
wine	5	5	5	5	5	5
acetic acid	5	5	5	5	5	5
olive oil	2	5	5	4	5	5
milk	5	5	5	5	5	5
coffee	5	5	5	5	5	5
tea	5	5	5	5	5	5
ammonia 10%	2	2	4	2	3	4
black ink	3	3	3	3	4	3
total	47	53	53	53	56	57

1… single layer coating; 2… double layer coating

CONCLUSIONS

The work presented shows a new wood coating system offering natural haptics of wood at increased mechanical performance in comparison to high quality non film forming floor coatings on the market. In addition potential of material and time savings of 50% could be shown by the newly developed floorcoating at equivalent performance in chemical resistance.

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