Performance of a water-borne stain on beech, spruce, MDF and OSB improved by plasma pre-treatment

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ABSTRACT

The performance of protective wood coatings, especially under outdoor weathering, depends on many factors, including the interface between coating and substrate. Sufficient interactions are particularly difficult to achieve on several types of wood-based composites, such as oriented strand boards (OSB) and medium-dense fibreboards (MDF). The interface between wood-based substrates and coatings can be modified and optimized by different means, e.g. by sanding or by using appropriate chemical primers. Plasma treatments represent a very interesting technique for surface modification, as they do not require additional reactants or chemicals, and therefore are an environmentally friendly alternative for optimizing the interface.

The studies were performed on Norway spruce (*Picea abies* (L.) Karst.) and common beech (*Fagus sylvatica* L.) wood, OSB and MDF using a commercial waterborne stain for exterior application and a commercial plasma unit (PlasmaTreat OpenAir®). Artificial accelerated weathering (AAW), water immersion and adhesion strength testing were conducted to test the performances of the surface systems formed by coating and surface, whereas their morphology and appearance was evaluated using confocal laser scanning microscopy (CLSM), gloss, and colour CIELAB system.

On coated solid spruce wood, the plasma pre-treatments yielded a slight reduction of the colour change during AAW and remaining gloss after AAW at approx. doubled values as compared to non-treated specimen. The initial bond strength of the coating of approx. 4 MPa was well preserved after AAW on plasma pre-treated samples, but reduced by 13 % on the non-treated specimens.

On coated beech wood, the colour change of the stain during AAW increased on plasma pre-treated specimen, whereas gloss, morphology, and bond strength were not influenced by the plasma pre-treatments.

On coated MDF specimen, the plasma pre-treatments yielded again a slight reduction of the colour change during AAW and a remaining gloss after AAW at approx. doubled values as compared to non-treated specimen. The weathering led to the formation of valleys and ridges on the surface of the non-treated specimens, but not on the plasma pre-treated ones. Further, the thickness swelling of the non-treated MDF specimen was larger by 12.7 % as compared to the thickness swelling of the plasma pre-treated specimen. The coating's adhesion strength on MDF was solely defined by the substrate material and did not show any differences due to plasma pre-treatments.

On surface finished OSB, the colour change of the stain during AAW was slightly lower on plasma pre-treated specimen, but gloss and morphology were comparable in all cases.

Keywords: Coating, weathering, plasma, wood, composite

Supplemental material

Table S1: Change of gloss value under 20°, 60° and 85° with increasing AAW time on plasma pre-treated (PTA) and non-treated (NT) coated MDF samples.

Treatment	Incident angle	Weathering time [h]			
		0	10	50	63
NT	20°	2.30 ± 0.00	0.40 ± 0.00	0.25 ± 0.07	0.15 ± 0.07
	60°	18.60 ± 0.14	3.10 ± 0.14	2.90 ± 0.14	2.60 ± 0.57
	85°	26.75 ± 0.92	1.80 ± 0.00	1.65’ ± 0.35	1.55 ± 0.21
PTA	20°	2.35 ± 0.35	0.35 ± 0.07	0.25 ± 0.07	0.35 ± 0.07
	60°	18.80 ± 1.13	3.80 ± 0.28	3.55 ± 0.49	3.75 ± 0.64
	85°	29.35 ± 2.33	3.50 ± 0.28	3.15 ± 0.21	3.25 ± 0.64

Table S2: Change of gloss value under 20°, 60° and 85° with increasing AAW time on plasma pre-treated (PTC) and non-treated (NT) coated spruce samples.

Treatment	Incident angle	Weathering time [h]			
		0	10	50	63
NT	20°	0.85 ± 0.07	1.00 ± 0.28	1.05 ± 0.35	0.90 ± 0.14
	60°	8.25 ± 1.63	8.60 ± 1.70	10.30 ± 1.84	9.35 ± 1.63
	85°	21.30 ± 9.48	13.05 ± 2.76	11.85 ± 3.89	13.85 ± 0.64
PTC	20°	1.85 ± 0.07	2.00 ± 0.42	1.95 ± 0.07	2.10 ± 0.14
	60°	19.25 ± 0.35	19.70 ± 2.40	20.35 ± 1.63	21.25 ± 1.63
	85°	31.80 ± 1.56	27.75 ± 3.75	25.90 ± 4.38	26.30 ± 0.42

Table S3: Change of gloss value under 20°, 60° and 85° with increasing AAW time on plasma pre-treated (PTC) and non-treated (NT) coated beech samples.

Treatment	Incident angle	Weathering time [h]			
		0	10	50	63
NT	20°	1.60 ± 0.28	1.30 ± 0.00	1.20 ± 0.14	1.45 ± 0.35
	60°	17.40 ± 2.69	13.80 ± 0.42	13.25 ± 1.06	15.85 ± 3.75
	85°	38.20 ± 7.07	26.60 ± 3.54	26.30 ± 0.57	28.40 ± 0.99
PTC	20°	1.50 ± 0.14	1.55 ± 0.35	1.25 ± 0.35	1.40 ± 0.14
	60°	16.85 ± 1.06	12.00 ± 4.81	15.40 ± 5.37	14.40 ± 2.55
	85°	40.35 ± 0.35	32.00 ± 1.41	26.95 ± 6.72	31.60 ± 2.12

Table S4: Change of gloss value under 20°, 60° and 85° with increasing AAW time on plasma pre-treated (PTE) and non-treated (NT) coated OSB samples.

Treatment	Incident angle	Weathering time [h]			
		0	10	50	63
NT	20°	3.00 ± 1.70	2.95 ± 2.76	2.70 ± 2.12	2.90 ± 2.12
	60°	22.15 ± 12.37	20.60 ± 15.56	21.20 ± 16.55	21.45 ± 16.05
	85°	36.70 ± 14.14	31.95 ± 16.62	25.60 ± 21.21	24.75 ± 18.31
PTE	20°	2.35 ± 1.06	2.35 ± 1.20	2.65 ± 1.34	2.40 ± 1.70
	60°	20.10 ± 7.21	20.70 ± 6.79	23.10 ± 8.49	21.00 ± 9.05
	85°	33.90 ± 6.79	27.75 ± 10.68	28.70 ± 13.15	26.50 ± 13.86