CORRELATION BETWEEN THE DEGRADATION OF POLYURETHANES EXPOSED TO ARTIFICIAL AND NATURAL WEATHERING

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Introduction

The presented results were accomplished during a DURACOAT project, funded under the CORNET Initiative. The main concept behind the project was to supply a criteria and guidelines for the selection of organic coating systems, applied on steel structures. Properties of the selected organic coating systems exposed to the real-life conditions (systems applied on bridges 10 to 20 years ago) were evaluated and compared with the results of the same systems submitted to artificial conditions during laboratory tests. The most reliable and suitable test methods were selected to enable quick evaluation of the anticorrosive properties of the coatings.

Tested systems comprised of 2-component polyurethane top-coat, based on acrylic resin, crosslinked with hexamethylene diisocyanate (HDI).

Experimental

Tested coating systems

Tests on actual bridge structures were carried out on bridges located in different corrosive conditions (Table 1).

Table 1. Characteristic of selected bridges

Location	Year	Category of corrosivity acc. to EN-ISO 12944	Designation of coating system*
Kosmin bridge/Poland	2003	C4	A
Tryncza bridge/Poland	2006	C4	B
Gora Kalwaria bridge/Poland	2000	C5I	C1
Gdański bridge/Warsaw, Poland	1999	C5I	C2
Kazimierz Wielki Bridge/Bydgoszcz, Poland	2000	C4	E
Fordon Bridge/Bydgoszcz/Poland	2001	C5I	F
Praski Bridge/Warsaw, Poland	2001	C4	G
* according to Table 2			

Coating systems, tested in laboratory and field conditions consisted of epoxy primers – differing in the type of anticorrosive pigments, the epoxy intermediate and the polyurethane topcoat crosslinked with hexamethylene diisocyanate (HDI) – in most cases based on acrylic resin (Table 2). Those systems were selected for the studies as they have passed the tests required by the polish Road and Bridge Research Institute and by the General Directorate for National Roads and Motorways and due to the universality of their application in different sites in Poland [1,2].

Table 2. Characteristic of tested coating systems

System	Coating type	Resin/curing agent/ anticorrosive pigment	Average thickness, µm	
			on bridges	for laboratory tests
A	Primer	EP (HS)/amine adduct/Al (2 –4 wt.%)	207	273
	Intermediate	EP (HS)/polyamine/Al		
	Topcoat	PUR (acrylic)/HDI		
B	Primer	EP (HS)/polyaminoamide/Al (2 wt.%)	447	291
	Intermediate	EP (HS)/polyaminoamide/Al (2 wt.%)		
	Topcoat	PUR (acrylic)/HDI		
C	Primer	EP/polyamide/Zn (75 wt.% in a dry coating)	C1: 282 C2: 410	282
	Intermediate	EP/polyamide/Al (1-2.5 wt.%)		
	Topcoat	PUR (acrylic/polyester)/HDI		
D	Primer	EP (HB)/polyamine/–	–	303
	Intermediate	EP (HB)/polyamine/–		
	Topcoat	PUR (acrylic)/HDI		
E	Primer	EP/polyamidoamine/Zn (94 wt.% in a dry coating)	281	286
	Intermediate	EP/polyaminoamide/MIOX (58 wt.%)		
	Topcoat	PUR (acrylic)/HDI/MIOX (47 wt.%)		
F	Primer	EP/polyaminoamide/Al (10 wt.%)	281	290
	Intermediate	EP/polyamine/MIOX (12 wt.%), Al (10wt.%), Zn phosphate (5 wt.%)		
	Topcoat	PUR (acrylic)/HDI		
G	Primer	EP/polyaminoamide/Zn phosphate (10.6 wt.%)	188	276
	Intermediate	EP/polyaminoamide/MIOX (36.5 wt.%)		
	Topcoat	PUR (acrylic)/HDI		

Investigations

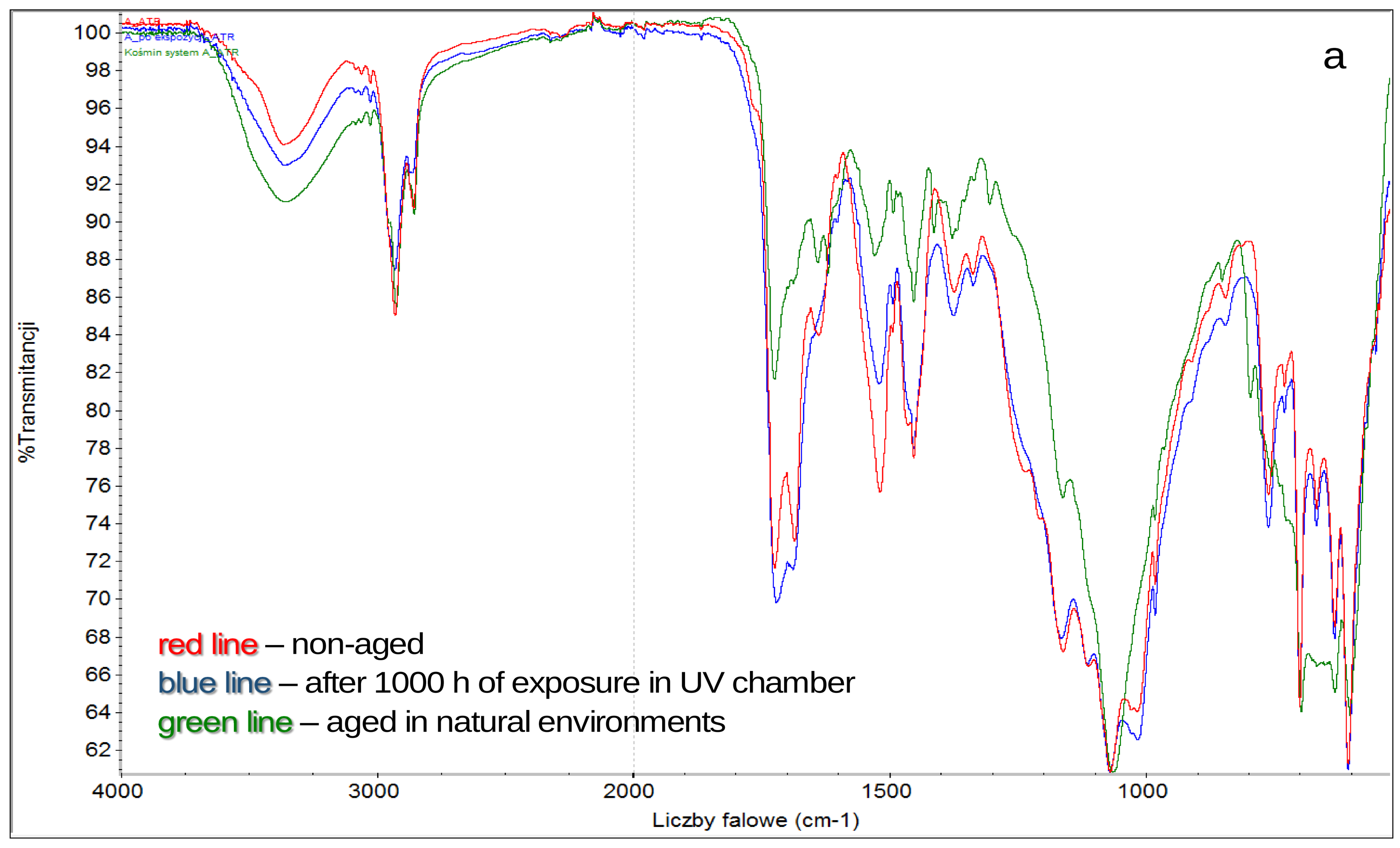
The methods applied to test the protective properties of coatings:

- artificial weathering in QUV chamber for 1000 h: (UV lamps 313, 4 h UV/60ºC + 4 h condensation/40ºC cycle);
- IR spectroscopy to evaluate degradation of the coatings after artificial and natural weathering.

Test results

Table 3. Chalking of top coats

System	Chalking degree acc. to EN-ISO 4628	
	In natural environment	After 1000 h of UV exposure
A	0	0
B	2	0
C	1–2	1
D	–	4
E	3	0
F	1	0
G	1	0



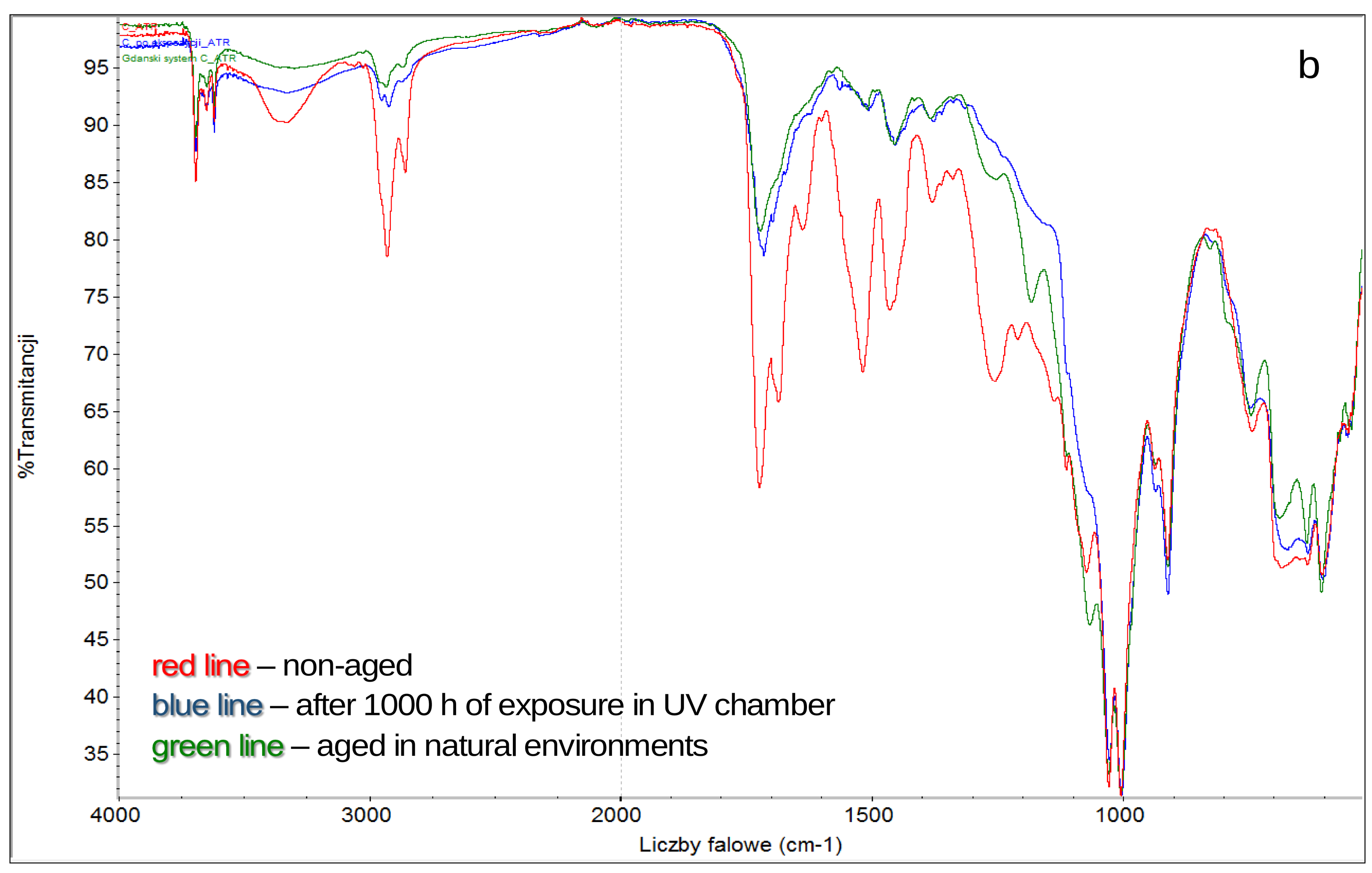


Fig. 1 . IR spectra of PU top-coats in two different systems: a) system A – no changes after aging, b) system C – changes after aging

Conclusions

- High matching of FTIR results for the new (after 1000 h exposition of artificial weathering) and in-service coatings was determined.
- Analysis of FTIR spectra reveals similarities between in-service (exposed to natural weathering conditions) and new coatings (after artificial weathering) as the same bands either remain unchanged (Fig. 1a) or disappear (Fig. 1b).
- There are differences between chalking of in-service bridge coatings and chalking evaluated for artificially weathered coatings (Table 3).
- A high degree of correlation was found between results of the research carried out so far and the actual behaviour of coatings during long-time operation in natural corrosion environment of C4–C5 corrosivity category.

Acnowledgments

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References

1. EN ISO 12944-5 Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems.
2. A. Krolikowska, Progr. Org. Coat. 39 (2000) 37–39.

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