

Multifunctional Dark-Colored Coating for Roof Renovation: Combining Corrosion Protection and Heat Reduction in a Single Application

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INTRODUCTION & AIM

In the face of growing challenges related to global warming, one of the most significant issues affecting both thermal comfort and energy efficiency in urban areas is the urban heat island effect (UHI). This phenomenon results in higher temperatures in cities compared to surrounding rural areas, primarily due to the properties of construction materials with low albedo, such as concrete, asphalt, and various roofing surfaces, which absorb and store heat. In densely built environments with limited green spaces, this effect becomes even more pronounced, leading to increased demand for air conditioning, higher energy costs, and worsened air quality.

The aim of this project was to address the problem of excessive heat accumulation on building roofs, particularly dark-colored roofs, which are prone to higher temperatures due to their tendency to absorb more solar radiation. Specifically, the research focused on evaluating the impact of coating composition on increasing the solar reflectance of polymeric anti-corrosion coatings applied directly to metal (DTM). Additionally, the project aimed to assess the durability of gray-colored coatings under artificial aging conditions. Properly designed coatings can significantly reflect solar radiation and help reduce the urban heat island effect.

Objectives of the project:

- **Develop modern roofing coatings** that combine enhanced corrosion protection with improved solar reflectance.
- **Evaluate the impact of coating composition** on increasing the solar reflectance of polymeric anti-corrosion coatings applied directly to metal (DTM).
- **Assess the durability of gray-colored coatings** under artificial aging conditions.

METHODS

New coating products were formulated containing various types of pigments that reflect solar radiation. The formulations used a binder based on a copolymer of vinyl chloride and vinyl isobutyl ether, as well as an anti-corrosion filler. The paints were prepared on a laboratory scale by dispersing in a bead mill. The resulting products were subjected to analysis in terms of their practical properties.

General formulation

Raw material	Content wt. %
Binder (40% solids)	65,59
Anticorrosion pigment I	7,80
Anticorrosion pigment II	6,45
Platelate filler	2,96
TiO ₂	3,64
Black pigment	0,99
Dispersing agent	3,23
Bentonite thickener	6,45
Surface additive	2,91

Characteristic of used pigments

Sample	Pigment used	Oil number, g/100 g	D ₅₀ [μm]
Gr-0	Iron black / carbon black 1,5 : 1,0 wt. ratio	Iron black 21,0 Carbon black 140,0	0,2
Gr-1	Cr _(x) Fe _(2-x-y) Al _(y) O ₃ ; hematite	9,0	1,5
Gr-2	Cr _(x) Fe _(2-x-y) Al _(y) O ₃ ; hematite	18,0	0,99
Gr-3	(Cr,Fe) ₂ O ₃ ; hematite	21,0	1,1
Gr-4	(Fe,Mn) ₃ O ₄ ; ferrite (spinel)	16,0	0,5
Gr-5	Cr _(x) Fe _(2-x-y) Al _(y) O ₃ ; hematite	12,0	1,5

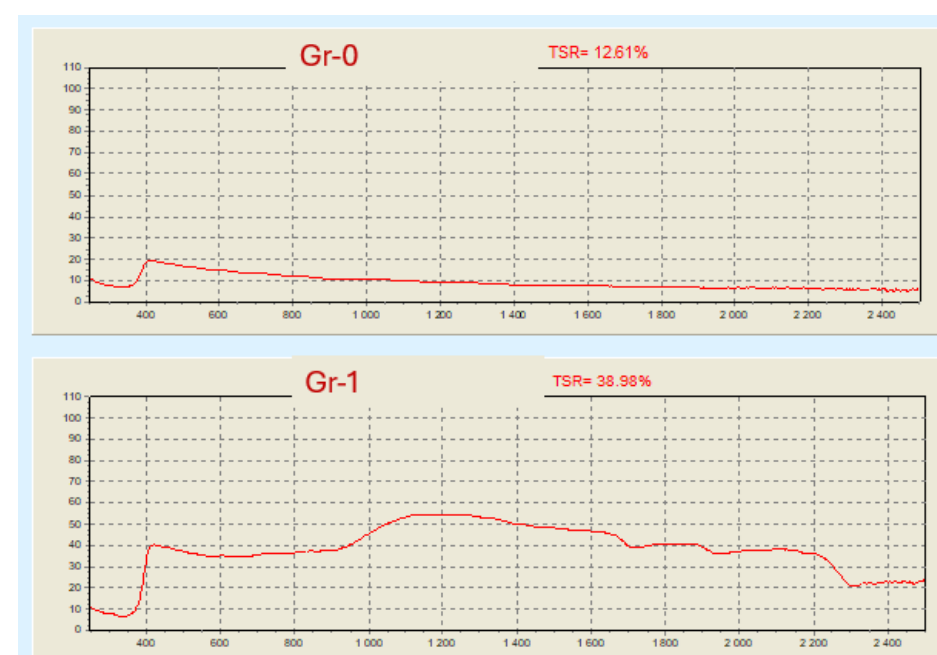
RESULTS & DISCUSSION

All tested coatings exhibited **very good adhesion, flexibility, and mechanical resistance**. The reference coating **Gr-0**, which did not contain IR-reflective pigments, showed the **lowest Total Solar Reflectance (TSR)** and the **highest surface temperature** after solar exposure.

Properties of coatings

Properties	Coating sample					
	Gr-0	Gr-1	Gr-2	Gr-3	Gr-4	Gr-5
TSR (before UV aging)	12,61	38,98	36,70	35,68	31,61	38,13
TSR (after UV aging)	13,11	38,30	36,96	35,55	32,12	37,85
Heat build up, °C	65,6	54,8	54,6	56,2	56,4	54,6
THE	0,905	0,897	0,896	0,896	0,896	0,900
SRI	10	44	40	39	34	43
Adhesion	0	0	0	0	0	0
Gloss at 60°	13,6	23,0	20,0	22,0	21,8	24,0
Impact strenght, cm	100	100	100	100	100	100
Persoz hardness, s	129	123	132	122	124	123

UV/VIS/NIR spectra



FTIR spectra before & after UV exposure



NSS salt spray test results

NSS exposure time [h]	Gr-0	Gr-1	Gr-2	Gr-3	Gr-4	Gr-5
120	0	0	0	0	0	0
288	0	1	1	1	0	0
360	1	1	1	1	1	0
456	1	1	1	1	1	0
504	1	1	1	1	1	0
936	3	2	2	1	1	0

Additionally, the coatings demonstrated **high thermal emissivity**, which supports effective heat dissipation from the surface. As a result, **Solar Reflectance Index (SRI)** values reached up to **44**, placing these dark coatings in a performance range comparable to light-colored materials.

In **corrosion resistance tests**, reflective coatings provided **better protection at damaged areas**, with defects appearing earliest on Gr-0 and Gr-3.

FTIR spectra confirmed chemical stability of the coatings before and after UV aging, regardless of the presence of reflective pigments.

These findings indicate that the developed coatings are **durable, functionally stable**, and capable of **reducing heat accumulation**, even in **dark color formulations**.

CONCLUSION

- The composition of the reflective pigment is a key factor determining the performance of cool anti-corrosion coatings. The best results were obtained using pigments based on Pigment Green 17, which provided both the highest TSR values and excellent long-term durability.
- The tested coatings exhibit promising properties aligned with current trends in the construction materials market. They contribute to lowering the temperature of building surfaces and envelopes, enhancing the thermal comfort of buildings and storage facilities — particularly those painted in dark colors.
- The presented coating solution can be successfully applied for the renovation of steel roofs, as well as modular and container buildings, effectively reducing operating costs associated with air conditioning in such structures.

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