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SELECTION AND EVALUATION OF SINGLE-LAYER COATING COMPOSITIONS IN CORROSIVE ENVIRONMENTS

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Abstract

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The objective of the work was to select a suitable methodology for accelerated corrosion tests of single-layer coating compositions (hereinafter referred to as CC), to assess the condition of coatings during corrosion tests and to evaluate the resistance of the monitored single-layer CCs after the completion of the tests in selected corrosive environments. The results were used for the determination of the potential use of the selected single-layer coating compositions in agricultural environments.
The following single-layer, water-based CCs were applied to sheet steel samples: V 2026, Aquapol_J and Denapox EZ. The following synthetic CCs were selected: AR 40-00, Krahokryl_J and ACS 20-ST. The resistance of these coatings was tested in 5 corrosive environments: in NaCl environment according to CSN EN ISO 7253, in SO_2 environment according to CSN EN ISO 3231 and in the environment of a condensation chamber with de-ionized water according to CSN 03 8131. To simulate agricultural environments, solutions of the Cererit fertilizer and pig semi-liquid manure were selected. The samples were left in the condensation chamber in aqueous environment according to CSN 03 8131 for 8 hours and then soaked in Cererit or semi-liquid manure and left in the laboratory environment for 16 hours.
Samples were evaluated according to CSN EN ISO 4628-1, 2, 3. The water-based CC Denapox EZ and the synthetic CC AR 40-00 reached the best results.

single-layer coating compositions, evaluation of coatings, protection from corrosion, water-based coating compositions, corrosive tests

At present, requirements are put on the development of coating systems that are environmentally friendly and that decrease the costs of production and application of paints while maintaining high corrosion resistance. The CSN EN ISO 11890 – 1, 2 standard was passed in the Czech legislation in order to limit the content of volatile organic compounds (VOC) in CCs. Thanks to that the volume of volatile organic compounds is decreased to the minimum or completely banned. Compounds are replaced by other, more environmentally-friendly substances and new directions are developed in the field of coating compositions.

Single-layer CCs follow this trend. As the title implies, these CCs only have one layer that fulfils the function of the undercoat as well as the topcoat with water being the dissolving agent, or with a limited volume of solvents. Thanks to that these CCs are environmentally friendly. Another advantage is saving time and thus money during the application and subsequent drying of the coating.

Single-layer water-based and synthetic CCs were selected on the basis of the aforementioned reasons to determine their resistance in the protection from corrosion and the possibility of use in agricultural environments.

MATERIAL AND METHODOLOGY

Sample material

Steel 11 321.21 was used as the sample material. It is structural steel with a guaranteed content of phosphor and sulphur, cold-rolled with minimal tensile strength 320 MPa according to CSN 42 0127. This steel is commonly used for vehicle bodies. Sheet steel with the dimension of 1 x 2 m and width of 0.6 mm was cut into samples with the dimension of 160 x 65 mm. The edges of the samples were ground and openings for hanging were drilled.

Preparation of samples

The preparation of samples was executed in accordance with CSN EN ISO 1514. The surface of samples was coarsened by SiC paper (120μm) and degreased in Perchloretylene Cl2C = CCl2. CCs in original packaging were mixed and thinned in the required ratios stated in the technical sheets of the products. Coating compositions were applied by a pneumatic spray gun in a spray box according to the instructions for use provided by the producers of the individual coating compositions immediately after the samples had been degreased and dried by a hot-air gun.

Determination of coating thickness according CSN EN ISO 2808

The thickness of the coating of all tested samples was measured before the exposure of the samples to the corrosive environments. The thickness of the coating was measured by a non-destructive measurement method based on the principle of magnetic induction by the PERMASCOPE MPO equipment by the Fisher Company. Each sample was measured at 3 different places of the surface; the result is mean value Ø and standard deviation S_x. The accuracy of this equipment is ± 0.5 μm.

Corrosion tests

5 corrosive environments were selected for testing the resistance of the selected CCs: standard tests in the environment of salt spray according to CSN EN ISO 7253, sulphur dioxide according to CSN EN ISO 3231 and de-ionized water according to CSN 03 8131. Furthermore, samples were tested by soaking in the solution of the Cererit fertilizer and pig semi-liquid manure and to accelerate corrosion samples were also exposed to the condensation chamber environment according to CSN 03 8131.

Test in the environment of salt spray according to CSN EN ISO 7253

It is an accelerated corrosion test according to CSN EN ISO 7253 in neutral salt spray. This environment simulates the effect of chloride ions acting in real conditions in the surroundings of roads sprayed with salt in winter.

Testing of samples was executed in the continual condensation chamber by Liebisch S 1000 M - TR. The volume of sprayed solution was regulated in the range of 1–2 ml per 80 cm^2* $hour^{-1}$.

The test was executed by the NSS method (Neutral Salt Solution). The trial solution was prepared by mixing de-ionized water with sodium chloride to make 5% solution. De-mineralized water or de-ionized water is water free from all ionic-soluble substances and silicon (usually present in the form of silicon dioxide). Its conductivity is below 0.1μS. cm^{-1}. The temperature of the solution during the test was 35 ± 2 °C. pH values were kept in the range from 6.5 to 7.2.

Organization of samples

Samples were placed according to the standard and checked in the interval of 1, 2, 4, 7, 10, 20 and 30 days.

After the test, samples were taken out of the chamber, rinsed and dried and subsequently evaluated according to CSN EN ISO 4628-1, 2, 3.

Significant data:

- Number of CC kinds = 6
- Number of samples tested on one CC = 20
- Total number of samples tested in NaCl = 6 × 20 = 120
- Time intervals for CC evaluation = 1, 2, 4, 7, 10, 20, 30 days
- Total test period = 30 days
- Temperature of the sprayed solution = 35 ± 2 °C
- Pressure in the chamber = 120 kPa
- Humidity in the testing chamber = 100%.

Test in the SO_2 environment according to CSN EN ISO 3231

Moist air containing sulphure dioxide in many metals quickly produces easily visible signs of corrosion, like that which occurs in industrial environments.

Thus it is often used for detection of pores or other sources of erosion in protective coatings and lack of corrosion resistance related to unsuitable composition of the alloy or inappropriate treatment.

Testing chamber

Tests were executed in a condensation chamber by Liebisch KBEA with the volume of 300 m^3. The equipment is fitted with hermetically closable door, temperature regulation, heating board device and sulphur dioxide batching. The chamber provides either continual or cyclical operation. The test was executed in the cyclical operation. The number of cycles was 30. One cycle included an 8-hour exposure to the SO_2 environment and 16-hour exposure to the environment of the laboratory atmosphere.

Samples were held by special holders. At the beginning of each cycle, the bottom of the testing chamber was filled with 2 ± 0.2 dm^3 of de-ionized water. Then, the chamber was hermetically sealed and 0.2 dm^3 of SO_2 gas was batched with the use of a gas burette. Subsequently, the heating of the water bath was launched with automatic regulation to 40 ± 3 °C. Water and sulphur dioxide were replaced for each cycle. The 8-hour exposure to the SO_2 environment was followed by a 16-hour exposure to the laboratory environment with relative air humidity of 70 % and temperature of 20 ± 5 °C.

Significant data:

- Number of CC kinds = 6
- Number of samples tested on one CC = 20
- Total number of samples tested in SO_2 = 6 × 20 = 120
- Time intervals for CC evaluation = 1, 2, 4, 7, 10, 20, 30 days
- Total test period = 30 days
- Temperature in the chamber = 40 ± 3 °C, relative humidity 100 %
- Temperature of the air in the laboratory was 20–23° at relative humidity of 70 %.
- SO_2 volume for 1 cycle = 0.2 dm^3.

Test in the condensation chamber according to CSN 03 8131

This test was executed in the condensation chamber with a de-ionized water environment. Samples were hung on 3 glass bars with the use of insulated wires. The test lasted continually for 30 days. Samples were checked in the same intervals as during the previous tests.

Significant data:

- Number of CC kinds = 6
- Number of samples tested on one CC = 20
- Total number of samples tested in H_2O = 6 × 20 = 120
- Time intervals for CC evaluation = 1, 2, 4, 7, 10, 20, 30 days
- Total test period = 30 days
- Water temperature = 35 ± 2 °C
- Relative humidity of the condensation chamber environment 100 %.

Test by soaking in Cererit

The liquid Cererit fertilizer was selected for the test of the resistance of coating compositions in a fertilizing environment. Composition: nitrogen – phosphorus – potassium 5 – 5 – 5. Theme: bezchloridové fertilizer for consumption of fruit, vegetables, bedroom, balcony and other ornamental plants and hops. It is used for fertilization and fertilization during vegetation. Non-standardized procedure was used for this test. To accelerate corrosion, samples were exposed in the chamber with de-ionized water for 8 hours according to CSN 03 8131 and then soaked in the Cererit solution for 3 minutes and then were exposed to the ambient atmosphere 16 hours. This cycle was repeated for 30 days.

Significant data:

- Number of CC kinds = 6
- Number of samples tested on Cererit = 20
- Total number of samples tested in Cererit = 6 × 20 = 120
- Time intervals for CC evaluation = 1, 2, 4, 7, 10, 20, 30 days
- Total test period = 30 days
- Temperature of water in the condensation chamber = 35 ± 2 °C, relative humidity 100%
- Temperature of the air in the laboratory was 20–23° at relative humidity of 50–60 %.

Cererit composition: nitrogen 5 % – phosphor 5 % – potassium 5 %. Designation: chloride-free fertilizer intended for the nourishment of fruit, vegetables, room, balcony and other plants and hop.

Test by soaking in semi-liquid manure

The environment of agricultural operations was simulated by soaking samples in semi-liquid manure. The test procedure was the same as in chapter 2.5.4.

Significant data: the same as for the previous test.

List of tested CCs

- Water-based CCs:
  - V 2026: acrylalkyd resin-based emulsion, shade: 0108 mouse grey, gloss – matte, content of non-volatile compounds at least 58 %.
  - Aquapol_J: polyurethane-alkyd emulsion, shade: 0100 white, gloss – matte, content of non-volatile compounds 50 %.
  - Denapox EZ: binary, epoxyacrylate hardener contains epoxide resins, shade: 0118 grey, gloss – semi-matte, content of non-volatile compounds of the hardened mixture 45–55 %.
- Synthetic CCs:
  - AR 40–00: alkyd with zinc-phosphate pigment, shade: 6001 green, gloss – semi-gloss, content of non-volatile compounds 56 %.
  - Krahokryl_J: styreneacryl, binary, shade: 0110 grey, gloss – semi-gloss, content of non-volatile compounds 45 %.
  - ACS 20-ST: binary polyurethane-acrylate with zinc-phosphate pigment, shade: 6018 green, gloss – semi-matte, content of non-volatile compounds 55 %.

Methodology of the evaluation of the resistance of selected CCs

The selected single-layer CCs were tested in the aforementioned corrosive environments and evaluated according to CSN EN ISO 4628-1, 2, 3. The evaluation concerned the quantity and size of blisters and the degree of rusting.

The quantity and size of blisters in the coating is expressed by a percentage ratio of the blistered area to the total area. The first figure shows the quantity (density) 0–5, see Tab. I. The figure after hyphen shows the size of blisters 0–5, see Tab. II and the bracket shows the degree of blistering (size) S0 – S5, see Tab. III.

I: *Numerical diagram for the classification of the quantity of defects*

Classification	Quantity of defects
0	None, i.e. no visible defects
1	Very little, i.e. small quantity of defects
2	Little, i.e. small but significant quantity of defects
3	Slight quantity of defects
4	Considerable quantity of defects
5	Surface densely covered by defects

II: *Numerical diagram for the classification of the size of defects*

Classification	Size of defects
0	Invisible without tenfold magnification
1	Visible only with up to tenfold magnification
2	Only just visible to the naked eye or with correction of visual defects
3	Clearly visible to the naked eye or with correction of visual defects (up to 0.5 mm)
4	0.5 mm to 5 mm
5	Larger than 5 mm

III: *Numerical diagram for the classification of the intensity of changes*

Classification	Intensity of changes
0	No changes, i.e. no visible change
1	Very small, i.e. only just observable change
2	Small, i.e. clearly observable change
3	Slight, very clearly observable change
4	Clear, i.e. considerable change
5	Very visible change

The quantity and size of blisters in the coating were evaluated according to the image standards in CSN EN ISO 4628 – 2.

The expression of degree of rusting R_i characterizes rust penetrating the surface and visible corrosion of the coating. The result is then expressed by degree of rusting of Ri 0 – Ri 5, see Tab. IV, and the bracket expressing the size of the individual corrosion points: S0 – S5 according to Tab. III.

IV: *Degree of corrosion and area with the occurrence of rust*

Degree of corrosion	Area with rust in %
Ri 0	0 to 0.05
Ri 1	> 0.05 to 0.5
Ri 2	> 0.5 to 1
Ri 3	> 1 to 8
Ri 4	> 8 to 40
Ri 5	> 40

Degree of rusting Ri was evaluated with the use of the image standards in CSN EN ISO 4628 – 3.

RESULTS AND DISCUSSION

Results of evaluation V 2026

Thickness of the coating according to CSN EN ISO 2808: Ø = 112 ± 14 µm. 101 samples were evaluated; 303 measurements of the thickness of the coating were executed in total.

The data stated in Tab. V imply that the V 2026 coating showed low resistance to the NaCl environment. There was occurrence of blisters on the entire surface and some blisters corroded in the SO_2 and H_2O environments. This coating had the best result in the Cererit environment where a small quantity of blisters occurred. In the semi-liquid manure environment, there was also corrosion on approx 15% of the surface in addition to blisters. This coating is not recommended to be used for the protection from corrosion in agricultural environments on the basis of the results shown in Tab. V.

Evaluation results for Aquapol_J

Thickness of the coating according to CSN EN ISO 2808: Ø = 97 ± 8 µm. 101 samples were evaluated; 303 measurements of the thickness of the coataing were executed in total.

The Aquapol_J coating showed the lowest resistance out of the tested CCs. The results stated in Tab. VI indicate that there was considerable corrosion in all environments. The results stated in Tab. VI imply that CC Aquapol_J is not suitable for use in agricultural environments.

Evaluation results for Denapox EZ

Thickness of the coating according to CSN EN ISO 2808: Ø = 101 ± 7 µm. Number of evaluated samples: 101. Number of measurements: 303.

The evaluation results of the water-based Denapox EZ coating together with the evaluation results of the AR 40-00 coating were the best out of the all tested CCs. This coating excellently withstood all tested corrosive environments. There was a small occurrence of blisters in the NaCl, SO_2 and H_2O environments but there was only slight corrosion in the SO_2 environment. There was no occurrence of blisters or corrosion on samples exposed to the environments simulating agricultural environments. However, there was a considerable occurrence of light stains, probably due to a chemical reaction of the coating with the environment.

V: *Evaluation results for V 2026*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1	no changes	no changes	several blisters 2 – 2(S2)
2	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
4	several blisters 2 – 2(S2) several corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
7	considerable quantity of blisters 3 – 3(S2) several corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)	small blisters on most of the surface 3 – 3(S2)
10	considerable quantity of blisters 3 – 3(S2) large quantity of corroded blisters Ri 3(S2)	considerable quantity of blisters 3 – 3(S2) corroded area <1% Ri 1(S2)	blisters on the entire surface 4 – 4(S3)
20	larger blisters on the entire surface 4 – 4(S3) most blisters heavily corroded Ri4(S4)	small blisters on the entire surface 3 – 3(S2) corroded surface <1% Ri 1(S2)	larger blisters on the entire surface 4 – 4(S3) some corroded blisters Ri 2(S3)
30	blisters on the entire surface 5 – 5(S4) corroded blisters on 70% of the surface Ri5(S4)	small blisters on the entire surface 5 – 5(S2) corroded surface 5% Ri 3(S2)	larger blisters on the entire surface 4 – 4(S3) some corroded blisters Ri 2(S3)

V: *continued*

Test duration [days]	Corrosive environment	
	Cererit	Pig semi-liquid manure
1	no changes	no changes
2	no changes	no changes
4	no changes	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)
7	no changes	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)
10	several blisters 2 – 2(S2)	blisters on a large area of the surface 3 – 3(S2) large quantity of corroded blisters Ri 3(S3)
20	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	blisters on a large area of the surface 4 – 4(S2) corroded blisters on 10% of the surface Ri 4(S2)
30	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	blisters on 40% of the surface 5 – 5(S2) corroded blisters on 15% of the surface Ri 4(S2)

VI: *Evaluation results for Aquapol_J*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1	several blisters 2 – 2(S2) Ri 4(S3)	several small blisters 2 – 2(S2) several corroded blisters Ri 2(S2)	no changes
2	several blisters 2 – 2(S2)	larger occurrence of blisters 3 – 3(S2) some corroded blisters Ri 3(S2)	no changes
4	blisters on a large area of the surface 3 – 3(S2)	larger occurrence of blisters 3 – 3(S3) some corroded blisters Ri 3(S3)	several small blisters 2 – 2(S2)
7	blisters on most of the surface 4 – 4(S3) some corroded blisters Ri 2(S2)	blisters on the entire surface 4 – 4(S3) large quantity of corroded of blisters Ri 4(S3)	several small blisters 2 – 2(S2) some corroded blisters Ri 2(S2)
10	blisters on the entire surface 4 – 4(S3) corrosion on 5% of the surface Ri 3(S3)	blisters on the entire surface 4 – 4(S3) corrosion on most of the surface Ri 4(S3)	larger quantity of blisters 3 – 3(S2) some corroded blisters Ri 2(S2)
20	blisters on the entire surface 4 – 4(S4) corrosion on 20% of the surface Ri 4(S4)	blisters on the entire surface 5 – 5(S3) corrosion on the entire surface Ri 5(S3)	blisters on most of the surface 3 – 3(S2) corrosion on 5% of the surface Ri 3(S3)
30	large blisters on most of the surface 5 – 5(S4) corrosion on 40% of the surface Ri 5(S4)	blisters on the entire surface 5 – 5(S3) corrosion on the entire surface Ri 5(S3)	blisters on the entire surface 4 – 4(S3) corrosion on 20% of teh surface Ri 4(S3)

VI: *continued*

Test duration [days]	Corrosive environment	
	Cererit	Pig semi-liquid manure
1	no changes	no changes
2	no changes	no changes
4	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
7	several blisters 2 – 2(S2) several corroded blisters Ri 2(S2)	several blisters 2 – 2(S2) several corroded blisters Ri 2(S2)
10	larger quantity of blisters 3 – 3(S2) some corroded blisters Ri 2(S2)	considerable quantity of blisters 3 – 3(S2) some corroded blisters Ri 2(S2)
20	considerable quantity of blisters 3 – 3(S2) corrosion on 5% of the surface Ri 3(S3)	blisters on the entire surface 4 – 4(S2) corrosion on 5% of the surface Ri 3(S3)
30	blisters on the entire surface 4 – 4(S3) corrosion on 20% of the surface Ri 4(S3)	blisters on the entire surface 5 – 5(S3) corrosion on 20% of the surface Ri 4(S3)

Evaluation results for AR 40-00

Thickness of the coating according to CSN EN ISO 2808: Ø = 110 ± 10 µm. 101 samples were evaluated; 303 measurements of the thickness of the coataing were executed in total.

The AR 40-00 coating together with the Denapox EZ coating reached the best resistance in the tested environments and out of the all CCs tested. There was a slight occurrence of corrosion in the semi-liquid manure when several blisters corroded. In the remaining environments, there was only a small occurrence of blisters. There were light stains without the signs of corrosion in the Cererit environment that were probably caused by a chemical reaction of the coating with the environment. On the basis of the results obtained, this coating may be recommended for use as anti-corrosion protection in agricultural environments.

VII: *Evaluation results for Denapox EZ*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1–10	no changes	no changes	no changes
20	several blisters 2 – 2(S2)	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	no changes
30	several blisters 2 – 2(S2)	several blisters 2 – 2(S3) some corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)

VII: *continued*

Test duration [days]	Corrosive environment	
	Cererit	Pig semi-liquid manure
1– 7	no changes	no changes
10	slight loss of pigment	slight loss of pigment
20	larger loss of pigment	loss of pigment on most of the surface
30	considerable loss of pigment on the entire surface	considerable loss of pigment on the entire surface

VIII: *Evaluation results for AR 40-00*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1–4	no changes	no changes	no changes
7	no changes	no changes	several blisters 2 – 2(S2)
10	several blisters 2 – 2(S2)	no changes	several blisters 2 – 2(S2)
20	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)	blisters on some of the surface 3 – 3(S3)
30	blisters on a large area of the surface 3 – 3(S3)	several larger blisters 3 – 3(S)	blisters on a large area of the surface 4 – 4(S3)

VIII: *continued*

Test duration [days]	Corrosive environment	
	Cererit	Pig semi-liquid manure
1–4	no changes	no changes
7	slight loss of pigment	several blisters 2 – 2(S2)
10	loss of pigment	several blisters 2 – 2(S2)
20	loss of pigment	several blisters 2 – 2(S3)
30	several blisters 2 – 2(S2) considerable loss of pigment	several larger blisters 2 – 3(S4) some corroded blisters Ri 2(S4)

Evaluation results for Krahokryl_J

Thickness of the coating according to CSN EN ISO 2808: Ø = 103 ± 9 µm. Number of evaluated samples: 101, number of measurements: 303.

There was only strong corrosion of the Krahokryl_J coating in the NaCl environment on 30% of the surface. In the SO_2 and semi-liquid manure environments, only some of the blisters corroded. Other environments only showed the occurrence of blisters without corrosion. On the basis of the evaluation results stated in Tab. IX, this coating is not recommended for use in agricultural environments.

Evaluation results for ACS 20-ST

Thickness of the coating according to CSN EN ISO 2808: Ø = 111 ± 5µm. Number of evaluated samples: 101, number of measurements: 303.

There was occurrence of large blisters, out of which some corroded, of the ACS 20-ST coating in the NaCl environment. There was only occurrence of blisters without any signs of corrosion in the SO_2 environment and in the environment of the condensation chamber with H_2O. The coating lost its pigment in the environments of the Cererit solution and pig semi-liquid manure, while that was not caused by corrosion but rather by a chemical

IX: *Evaluation results for Krahokryl_J*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1–2	no changes	no changes	no changes
4	several blisters 2 – 2(S2)	no changes	no changes
7	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)	no changes
10	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
20	blisters on a large area of the surface 3 – 3(S2) large quantity of corroded blisters Ri 3(S3)	several larger blisters 2 – 2(S3) some corroded blisters Ri 2(S3)	several blisters 2 – 2(S2)
30	blisters on the entire surface 4 – 4(S3) corrosion on 30% of the surface Ri 4(S3)	larger occurrence of blisters 3 – 3(S3) some corroded blisters Ri 2(S3)	larger occurrence of blisters 3 – 3(S3)

IX: *continued*

Test duration [days]	Corrosive environment	
	Cererit	Pig semi-liquid manure
1–2	no changes	no changes
4	no changes	no changes
7	several blisters 2 – 2(S2)	no changes
10	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
20	larger occurrence of blisters 3 – 3(S3)	several blisters 2 – 2(S2)
30	blisters on most of the surface 4 – 4(S3)	larger occurrence of blisters 3 – 3(S3) some corroded blisters Ri 3(S3)

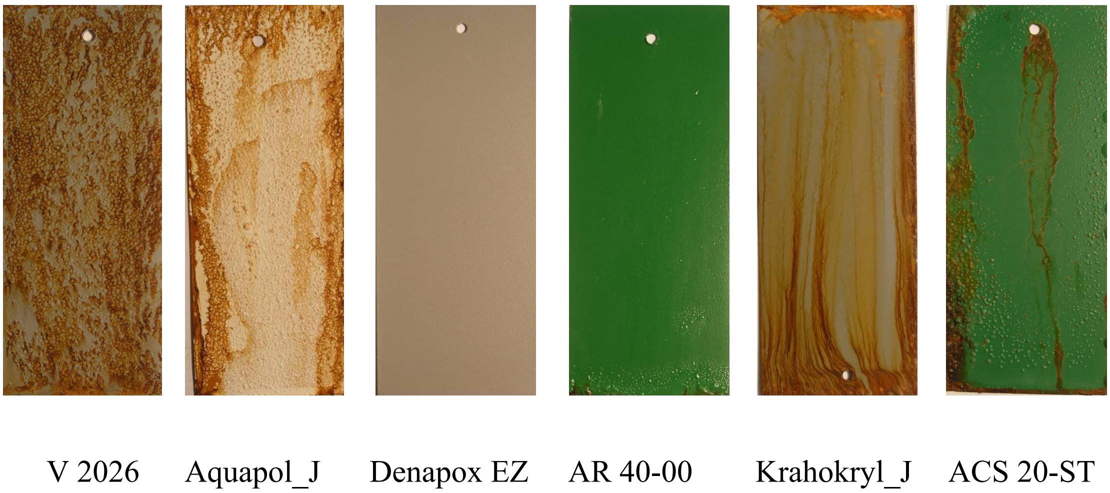
X: *Evaluation results for ACS 20-ST*

Test duration [days]	Corrosive environment		
	NaCl	SO_2	H_2O
1	no changes	no changes	no changes
2	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	no changes	no changes
4	several blisters 2 – 2(S2) some corroded blisters Ri 2(S2)	no changes	no changes
7	considerable quantity of blisters 3 – 3(S2) some corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)	no changes
10	considerable quantity of blisters 3 – 3(S2) some corroded blisters Ri 2(S2)	several blisters 2 – 2(S2)	several blisters 2 – 2(S2)
20	blisters on the entire surface 4 – 4(S3) corrosion on 5% of the surface Ri 3(S3)	larger quantity of blisters 3 – 3(S3)	several blisters 2 – 2(S2)
30	blisters on the entire surface 4 – 4(S3) corrosion on 8% of the surface Ri 3(S3)	blisters on the entire surface 4 – 4(S3)	larger quantity of blisters 3 – 3(S3)

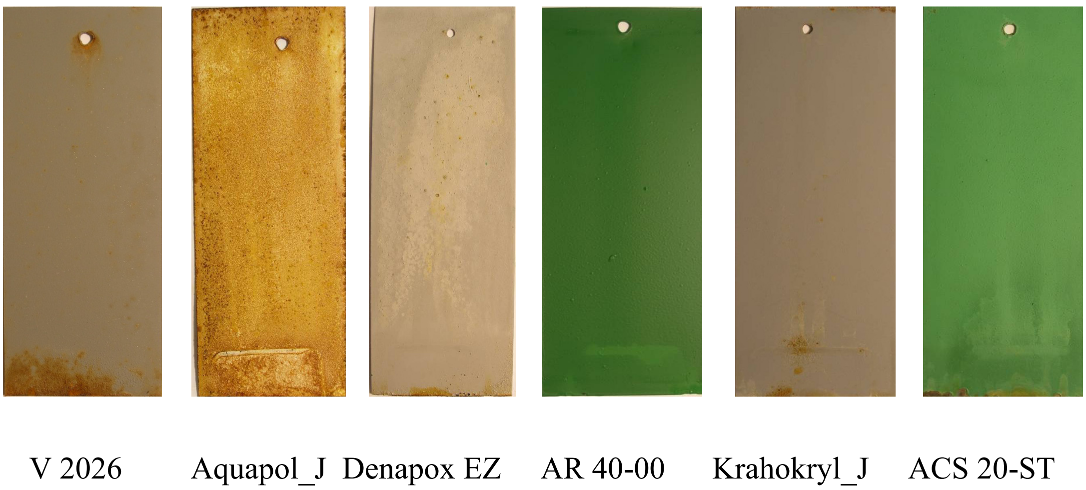
X: *continued*

Test duration [days]	Corrosive environment	
	Cererit	**Pig semi-liquid manure**
1	no changes	no changes
2	no changes	no changes
4	no changes	slight loss of pigment
7	no changes	loss of pigment
10	loss of pigment	loss of pigment
20	loss of pigment	large loss of pigment
30	large loss of pigment	loss of pigment on the entire surface

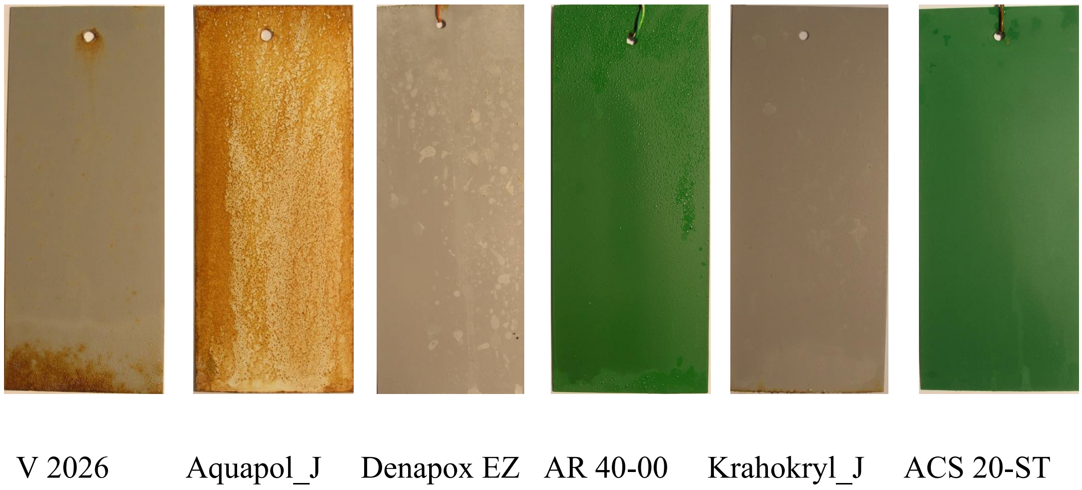
reaction of the coating with the environment. On the basis of the evaluation results stated in Tab. X, this coating may be recommended for use in anti-corrosion protection of metals in agricultural environments.



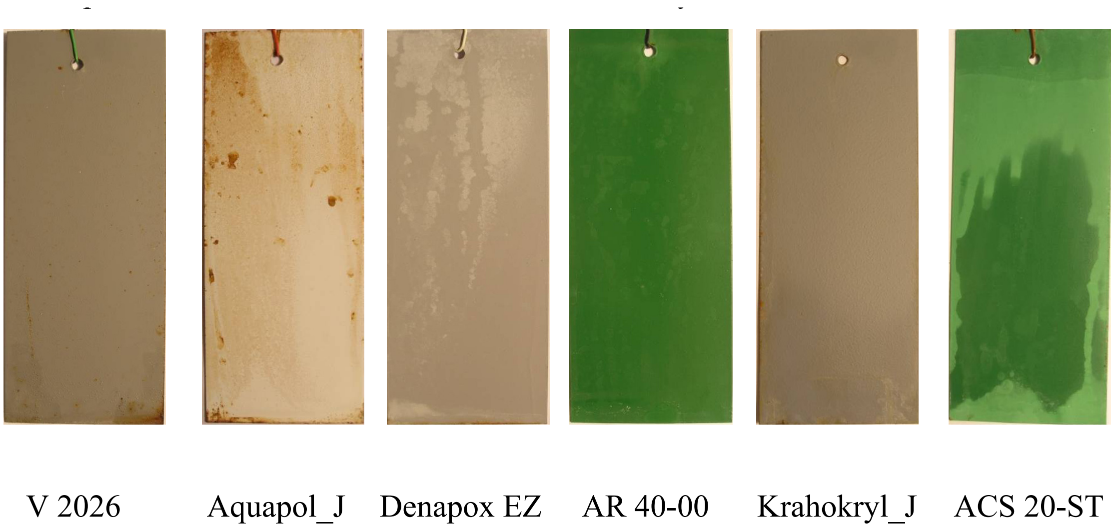
1: *Samples from the environment of NaCl for 30 days*



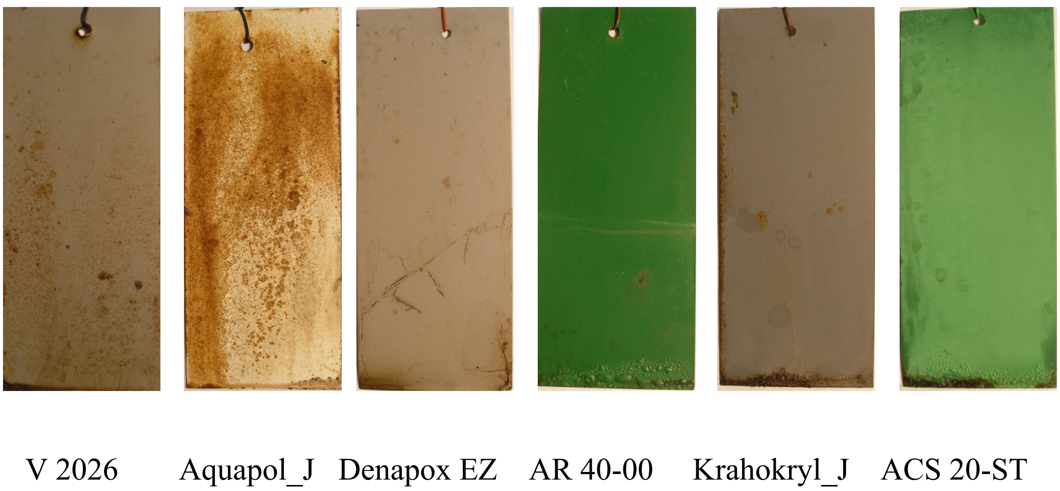
2: *Samples from the environment of* SO_2 *for 30 days*



3: *Samples from the environment of H_2O for 30 days*



4: *Samples from the environment of Cererit for 30 days*



5: *Samples from the environment of Cererit for 30 days*

CONCLUSION

Based on the achieved results of the evaluation of the stated CCs in the proposed environments and tests, it is possible to recommend the use of the following single-layer CCs in the industrial and agricultural environment: water-based single-layer CC Denapox EZ, synthetic single-layer CC AR 40-00 and ACS 20-ST. These coating compositions may be used, for instance, for the construction of buildings and facilities in agriculture or for machine parts that are not exposed to the abrasive effects on the coated surface. Denapox EZ and AR 40-00 on the basis of tests can be recommended as suitable for corrosion protection of machinery and equipment in agricultural operations.

The proposed methodology for corrosion tests for the selected single-layer CCs completely fulfilled its purpose. The executed tests demonstrated the possibility of using single-layer CCs in agricultural environments.

SUMMARY

The article deals with the evaluation of selected water-based and synthetic single-layer coating compositions in corrosive environments simulating the operating conditions of agricultural operations. The resistance of the selected coatings was tested in 5 corrosive environments: NaCl environment according to CSN EN ISO 7253, SO_2 environment according to CSN EN ISO 3231 and the environment of a condensation chamber with de-ionized water according to CSN 03 8131. To simulate agricultural environments, solutions of the Cererit fertilizer and pig semi-liquid manure were selected. The samples were evaluated according to CSN EN ISO 4628-1, 2, 3. The water-based CC Denapox EZ and the synthetic CC AR 40-00 reached the best results.

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