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EUROCORR
EUROPEAN CORROSION CONGRESS

CORTEC CORPORATION
Environmentally Safe VpCI®/MCI® Technologies

EcoCortec®
FIRST CROATIAN BIOPLASTICS PLANT

A new generation of Vapor phase Corrosion Inhibiting (VpCI) films with recycled content

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Current Regulations

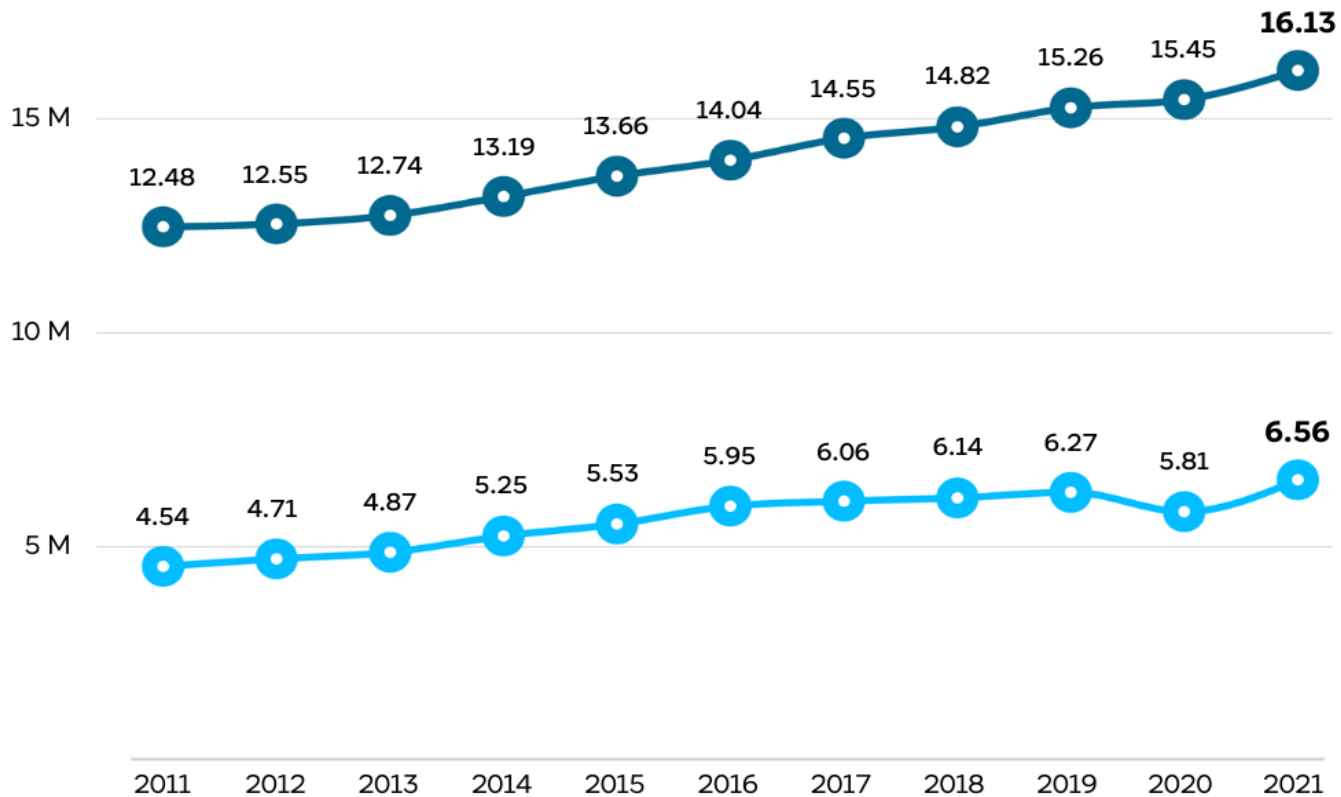
The Packaging and Packaging Waste Regulation (PPWR)

The Regulation aims to reduce the environmental impact of packaging and at the same time harmonize packaging rules throughout the EU

Recycling Targets

- Packaging accounts for 40% of plastics and 50% of paper used in the EU. The new agreement includes packaging reduction targets for member states, reaching 5% by 2030, 10% by 2035 and 15% by 2040 through re-use and recycling, and mandates the reduction in the amount of plastic waste
- One of the targets proposed for plastic packaging (that is not contact sensitive) is that it should contain 35% PCR by 2030 (some special packaging products are exempted).

Plastic waste produced and recycled in the EU, in million tonnes (2011–2021)



European Parliament

Source: Eurostat [env_waspac] · most recent data available (2021)

Impact on Businesses

- Plastic levy on non-recycled plastic packaging waste to reduce waste and fund EU budgets, with rates set at EUR 0.80 per kg

- New product formulations / increased interest in PE recycling and recycled raw materials

Recycled Plastic

PIR - an abbreviation for Post Industrial Recycled / raw material made from waste generated within the industry.

PCR - an abbreviation for Post Consumer Recycled / the raw material made from waste from the consumer/end user.

PCRPE – Post Consumer Recycled Polyethylene

Challenges in using recycled plastics

- Complex challenges addressing substitutability for recycled plastics

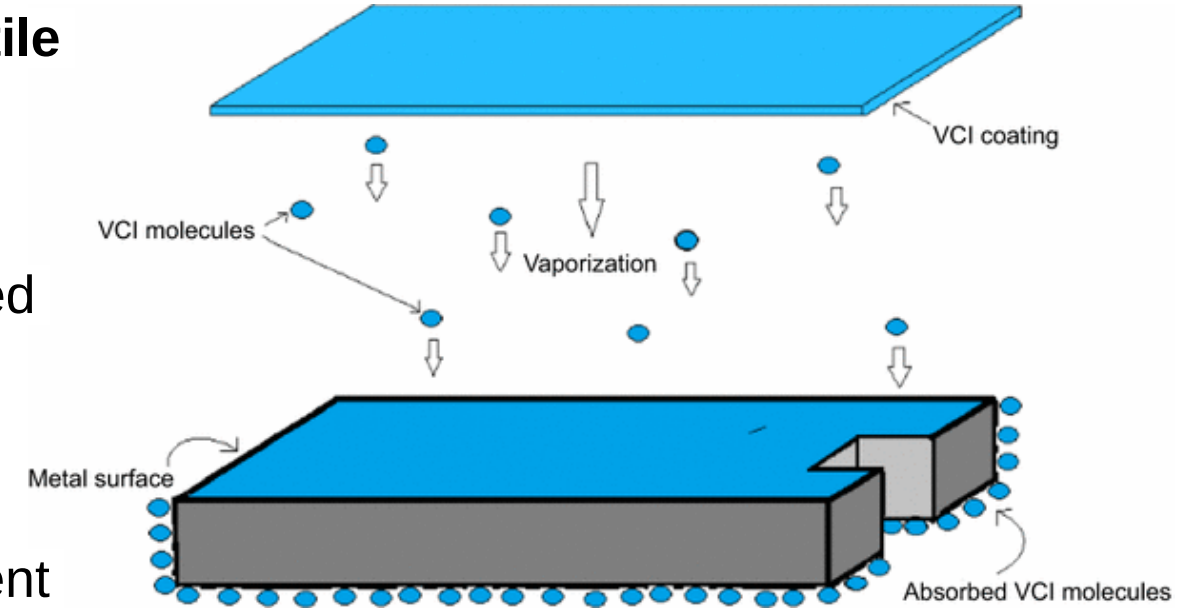
  Difficulties in sorting different grades (LDPE, LLDPE, MDPE, HDPE)
  Waste treatment contamination
  Presence of additives
  Exposure to environmental conditions

- Technical properties of the recycled material

Vapor Corrosion Inhibitors

- NACE International Standard TM0208 defines **volatile corrosion inhibitor** (VCI) as a chemical substance that acts to reduce corrosion by a combination of
  - volatilization from a VCI material,
  - vapor transport in the atmosphere of an enclosed environment,
  - condensation onto surface in the space.

- VCIs come in various formulations that are dependent on the type of system they will be used in; for example, films, oils, coatings, cleaners, etc.



VCI Packaging Films

- Packaging materials for storage and transportation of metals parts
- Impregnated with VCIs to provide corrosion protection in addition to the basic physical barrier
- VCI-containing PE films are recyclable
- Can be made from recycled plastic

Experimental Procedure

MATERIALS

- Commercial low-density PE (LDPE) and linear low-density PE (LLDPE)
- VCIs composed of proprietary formulations
- In-house reprocessed resin (PIR)
- Commercially available post-consumer recycled resin (PCRPE) - LDPE compound based on post-consumer (PCR) material

METHODS

- Blown film extrusion line, using standard melt processing temperatures in the range of 160 to 200°C
- The coextrusion die produced three layers-fed by three different extruders.
- The general film construction included thickness/wt.% of 25/50/25 for the three layers.
- Three different resin blends: LDPE/LLDPE/VCI base, with no recycled material (VCI R0), with 20% PIR (VCI PIR20), with 30% PCRPE (VCI PCR30)
- Same film size was extruded / 100 µm

Experimental Procedure

EVALUATION

- **Changes in corrosion inhibiting and mechanical properties**

- Razor Blade Test, E-001 (company method)
- NACE Standard VIA Test, TM0208-2018
- Thickness – ASTM D6988
- Tensile Strength at Break – ASTM D882-02
- Elongation at Break – ASTM D882-02
- Yield Strength – ASTM D882-02
- Tear Strength – ASTM D1922
- Impact puncture – ASTM D3420

Results

Razor blade test results

Evaluates the ability of a corrosion inhibitor to protect metal when in direct contact, in the presence of moisture

Table 1: Razor Blade Test- Carbon Steel Panels

Sample	Panel #1	Panel #2	Panel #3	End Result
VCI R0	Pass	Pass	Pass	Pass
VCI PIR20	Pass	Pass	Pass	Pass
VCI PCR30	Pass	Pass	Pass	Pass
Control	Fail	--	--	Fail

Table 2: Razor Blade Test- Copper Panels

Sample	Panel #1	Panel #2	Panel #3	End Result
VCI R0	Pass	Pass	Pass	Pass
VCI PIR 20	Pass	Pass	Pass	Pass
VCI PCR 30	Pass	Pass	Pass	Pass
Control	Fail	--	--	Fail

Razor Blade – Carbon Steel

Figure 1: Razor Blade Test- Carbon Steel for sample VCI PCR 30% at the beginning (left) and end (right) of the test.

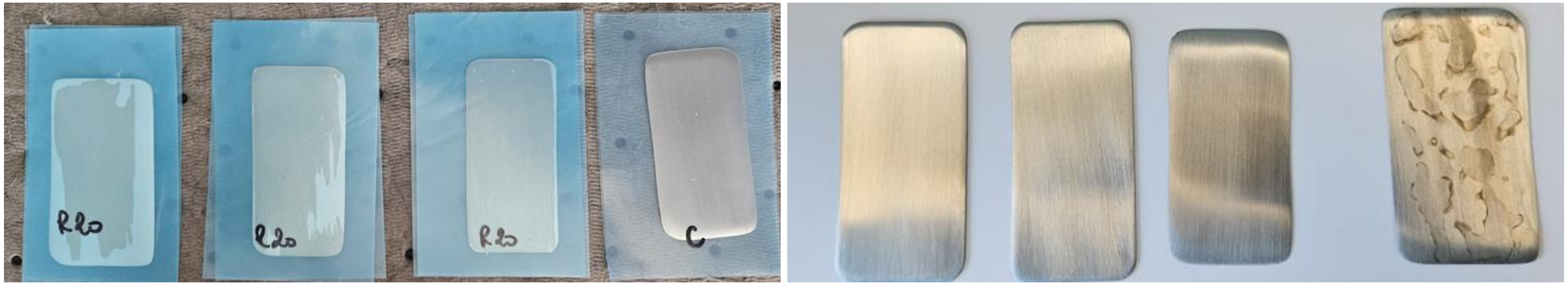


Figure 2: Razor Blade Test- Carbon Steel for sample VCI PIR 20% at the beginning (left) and end (right) of the test.

Razor Blade – Copper

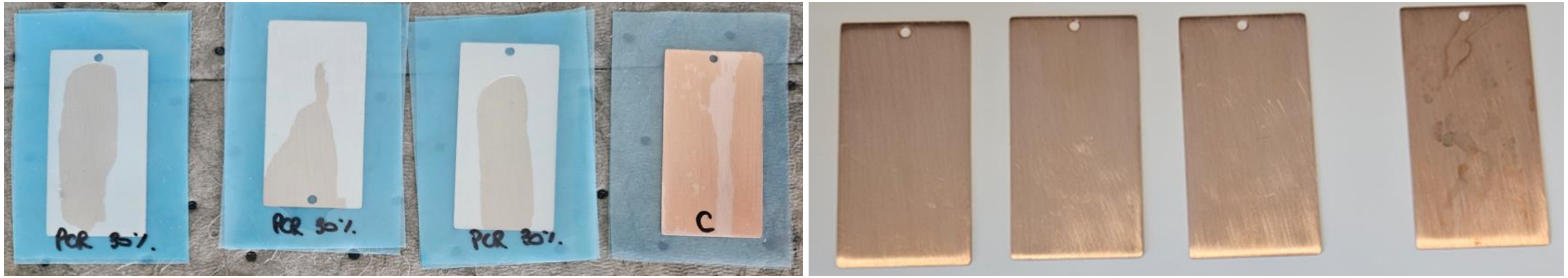


Figure 1: Razor Blade Test- Cooper for sample VCI PCR 30% at the beginning (left) and end (right) of the test.

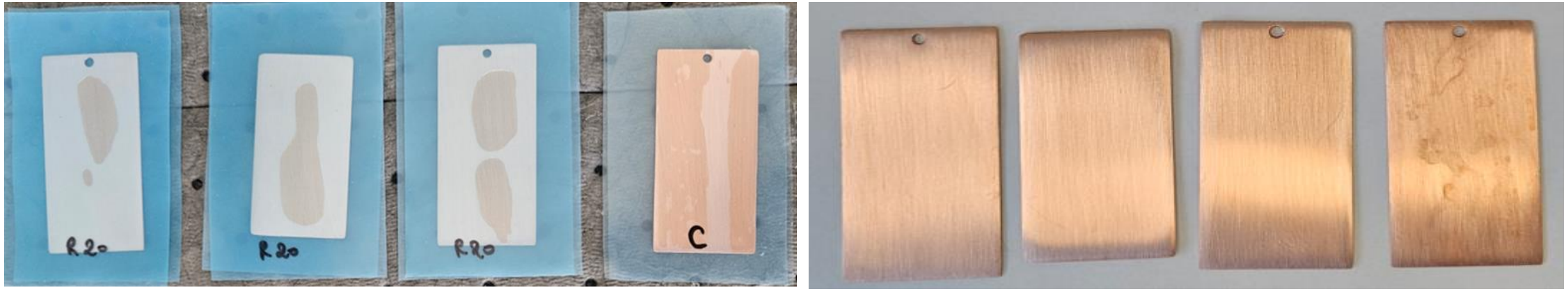
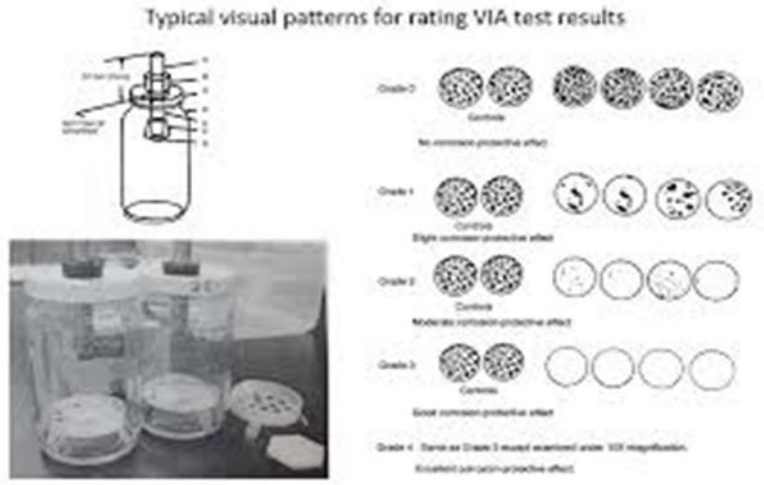


Figure 2: Razor Blade Test- Cooper for sample VCI PIR 20% at the beginning (left) and end (right) of the test.

VIA NACE TM0208

Table 3: VIA NACE Test results

Sample	Plug #1	Plug #2	Plug #3	End Result
VCI R0	Grade 3	Grade 3	Grade 3	Pass
VCI PIR 20	Grade 3	Grade 3	Grade 3	Pass
VCI PCR 30	Grade 3	Grade 3	Grade 3	Pass
Control	Grade 0	--	--	Fail



VIA NACE TM0208

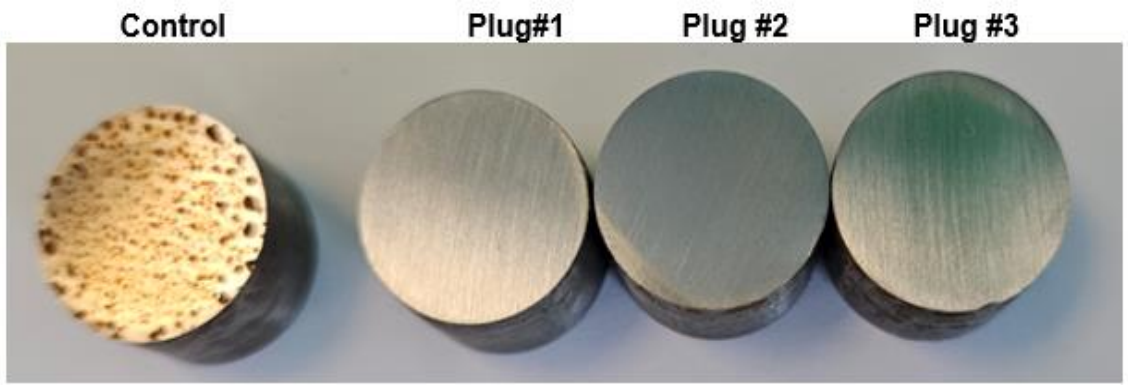


Figure 3: VIA NACE Test result for sample VCI PCR 30%.

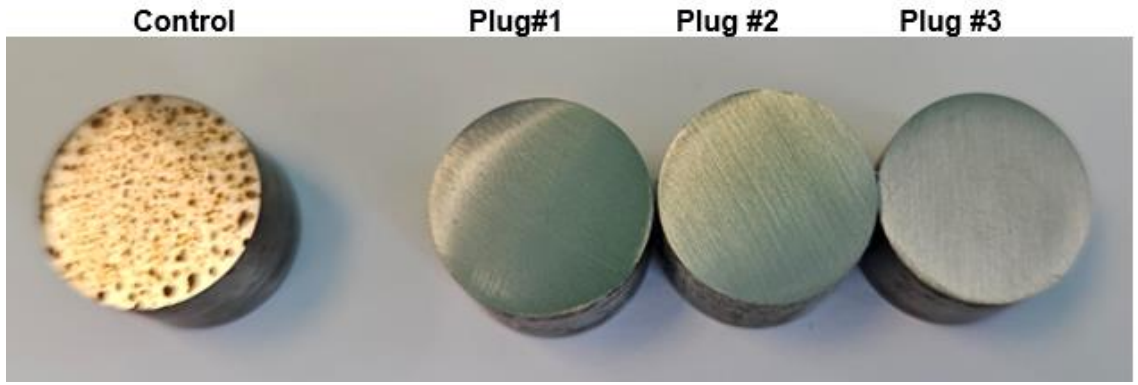


Figure 4: VIA NACE Test result for sample VCI PIR 20%.

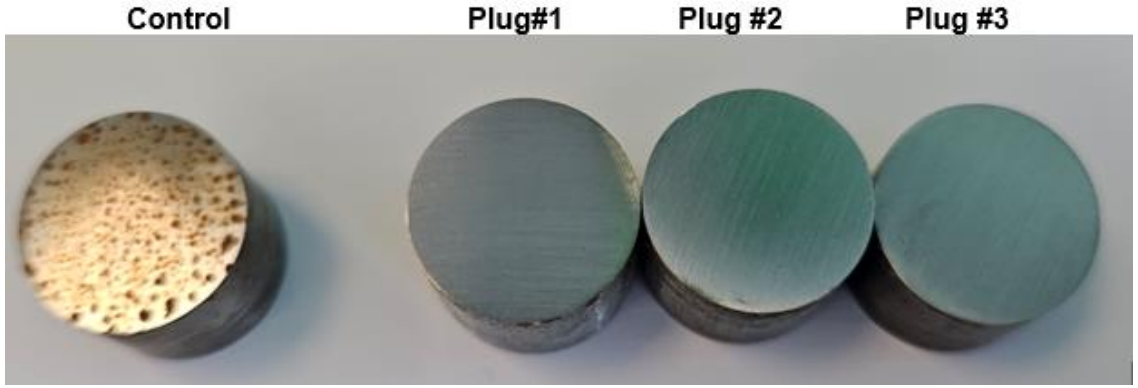


Figure 5: VIA NACE Test result for sample VCI R0 %.

Table 4: Mechanical properties test results

Properties		Test method	Units	VCI R0	VCI PIR20	VCI PCR30
Thickness	MD	ASTM D6988	µm	111,67	108,17	113,33
	CD			112,00	108,67	107,17
Tensile Strength at Break	MD	ASTM D882	MPa	19,223	18,053	18,181
	CD			20,574	21,886	21,840
Percent Elongation at Break	MD	ASTM D882	%	554,82	504,49	559,79
	CD			895,01	901,06	892,54
Yield Strength	MD	ASTM D882	MPa	12,89	12,57	11,88
	CD			8,65	9,33	9,73
Tear Strength	MD	ASTM D1922	mN	5127,36	4604,16	4604,16
	CD			17684,16	16742,40	16736,48
Impact Elmendorf		ASTM D3420	mN	16271,52	16428,48	15696,00
			J	1,40	1,42	1,35
BUR				2,39	2,39	2,39

Conclusion

- ✓ Based on the VIA NACE TM0208 standard, both VCI films with recycled content demonstrated high corrosion inhibition efficiency.

- ✓ When compared to standard VCI film, with no post-industrial nor post-consumer recycled material, both films showed comparable mechanical properties.