

Advanced hybrid sol-gel coatings for aeronautical applications Industrials needs and new developments



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Context

- Needs for aeronautical end-users to use new surface treatments and coatings.
- Combine multifunctional properties that cannot be achieved by traditional organic coatings : transparency, mechanical resistance, protection, adhesion, ...
- Versatility of hybrid organic-inorganic coatings by tailoring precursors, synthesis, process and properties.

Top-Coat

Cr^{VI} primer

Conversion

Cr^{vi} ou Crⁱⁱⁱ

AA 2024

- Must to be coated & cured with traditional system :
 - Spraying or dipping.
 - Thermal, UV or IR curing.

Chemistry

- Precursors
- Synthesis
- Catalysis Kinetics
- Solvent

Sol-gel process synthesised Materials

- Bottum-up Chemistry.
- 3-dimensional oxyde network
- Involving hydrolysis and condensation reaction.
- Involving the use of metal alcoxyde (Si, Zr, Ti, Al, V, ...

Properties

- Surface thermodynamics
- Thermal stability
- Mechanical

Process

Optical



- spraying, ... Curing
- Coating, preform, aerogel

Processing : dip-coating,

Anticorrosion primer

Context & Needs:

- Replace Cr VI primer.
- REACH sunset in 09/2017 possible extension to 202X
- Reach compliant coating
- Iso performance (vs current system)
- Reduction of layer/ Lightweight system

Properties		Results	
Thickness		10 – 20 µm	14 µm
Adherence	ISO 2409	GT0	GT0
Scratch Resistance	ISO 1518 ≥ 1 500 g		OK
Flexibility	ISO 1519	Ø 2 mm	KO
H ₂ O Resistance	ISO 2812	No defects ≥ 1 200 g (ISO 1518) GT1 (ISO 2409)	ОК
Skydrol Resistance	ISO 2812	No defects ≥ 1 200 g (ISO 1518) GT1 (ISO 2409)	OK
Humidity Resistance	ISO 6270	No defects ≥ 1 200 g (ISO 1518) GT1 (ISO 2409)	OK
Neutral Salt Spray	ISO 9227	No pit (3 000 h)	No pit
Filiform Corrosion Resistance	EN 3665	≤ 2 mm (1 000h)	≤ 2 mm



Coated AI 2024 T3

3000h NSST

Top-Coat

Rescoll

Cr free primer

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Easy to clean coating

Context & Needs :

- Design of new Horizon 2020 Cockpit.
- Minimize the number of knobs & switches.
- Replace by tactile display.
- Easy-to-clean surface.
- Resistant to abrasion & wiping.
- Ageing.







Properties	Target	RESCOLL AS coating
Water contact angle	> 90°	112°
Oleic acid contact angle	> 65°	75°
Abrasion 500 cycles load 970g &CS10 rubber (¼")	$\Theta_{water} > 90^{\circ}$ $\Theta_{OIAc} > 65^{\circ}$	$\Theta_{water} = 110^{\circ}$ $\Theta_{OIAc} = 70^{\circ}$
Wipping 20000 cycles at 15cycles/min load 850g - Gekamicro fabrics	$\Theta_{water} > 90^{\circ}$ $\Theta_{OIAc} > 65^{\circ}$	$\Theta_{water} = 110^{\circ}$ $\Theta_{OLAC} = 70^{\circ}$
Ageing 1000h @70°C & 85%HR	$\Theta_{water} > 90^{\circ}$ $\Theta_{OIAc} > 65^{\circ}$	$\Theta_{water} = 110^{\circ}$ $\Theta_{OL Ac} = 70^{\circ}$



Water contact angle of As coating : 112°



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Anti-erosion coating

Context & needs :

- Minimize aerodynamic drag create by defect (erosion, contamination, ...).
- Protect traditional paint scheme by an highly resistant & multifunctional clear-coat.

RESCOLL would like to acknowledge the consortium (CORI, BLUESTAR Silicone, DASSAULT Aviation).

Clear-coat must be transparent & bright, protect from scratch, present hydrophobic properties.

Properties	Targe	et	RESCOLL clear-coat ⁽¹⁾		
Brightness	> 90 UB @60°		> 90 UB @60°	Future improvements :	
Transparency	> 90%		92%	 UV Ageing resistance 	
Adhesion	ISO 2409	GT0	GT0	improvement.	
Hardness	ISO 15184	> 5H	8H	 Correlation between 	
Roughness	Ra < 0,8µm		Ra = 0,µm	Hardness and Erosior	
Water contact angle	> 90	0	95°	Ontimisation of	
Ageing in suntest 1400h exposure to sunlight spectrum	ΔE < 0,6		ΔE < 3	synthesis condition, precursor choice &	
Erosion	Minimal wei	gth loss	Not yet realised	process.	

FENICS project had been performed within the framework of CORAC French national grant from 2012 to 2014 Recherche

Thermal resistant coating

Context & Needs :

- Customer needs : aesthetic coating with durability when subjected to high temperature (> 200°C).
- Replace organic clear-coat by sol-gel coating.
- Color stability after thermal shock.
- Satisfy Aeronautical specification (adhesion, mechanical resistance chemical resistance).









Thermal resistant coating after thermal ageing => no damages

Properties	Target		RESCOLL HT clear-coat
Brightness	> 85 UB @60°		90 UB @60°
Adhesion	ISO 2409	GT0	GT0
Scratch resistance	ISO 1518	> 1500g	> 1500g
Chemical resistance 7 days in H2O @23°C 1000h in Kerosene @23°C	No Color change No Brigthness change Adhesion Scratch resistance	ΔE < 1 >85UB @60° GT0 > 1500g	ΔE = 0,2 88UB @60° GT0 > 1500g
Thermal Ageing 24h @ 270°C		ΔE < 3 >85UB @60° GT0 > 1500g	80 UB @60° ΔE = 1 GT0 800g

n on.

(1) Coated on chemically etched Aluminum 2024T3





CLOCHETTE project had been performed within the framework of RAPID French national grant from 2013 to 2017. RESCOLL would like to acknowledge the consortium (MÄDER coatings, AIRBUS Helicopters and the DGA)

Conclusion

CLEANSK

Sol-Gel synthesized coatings offer a wide range of application for aeronautical industries. • Up-scale and Qualification is now being possible for such kind of technology in this fields

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