

Anquamine[®] 401 and Anquamine[®] 419 : Waterborne amine hardeners as eco-friendly and sustainable technology for protective coatings



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Webinar

Presenter:
Katharina Karns

Co-author:
M.-E. Inhestern

Evonik is a technology leader in Epoxy Curing Agents

- Full toolbox of amine-based curing agents, including special diluents, resins and modifiers
- Offerings for ambient- and heat-cure applications
- Tailor-made solutions for various industries and end markets

MARKETS

Marine
Coatings



Protective
Coatings



Construction
and Flooring



Composites &
Adhesives



PRODUCTS

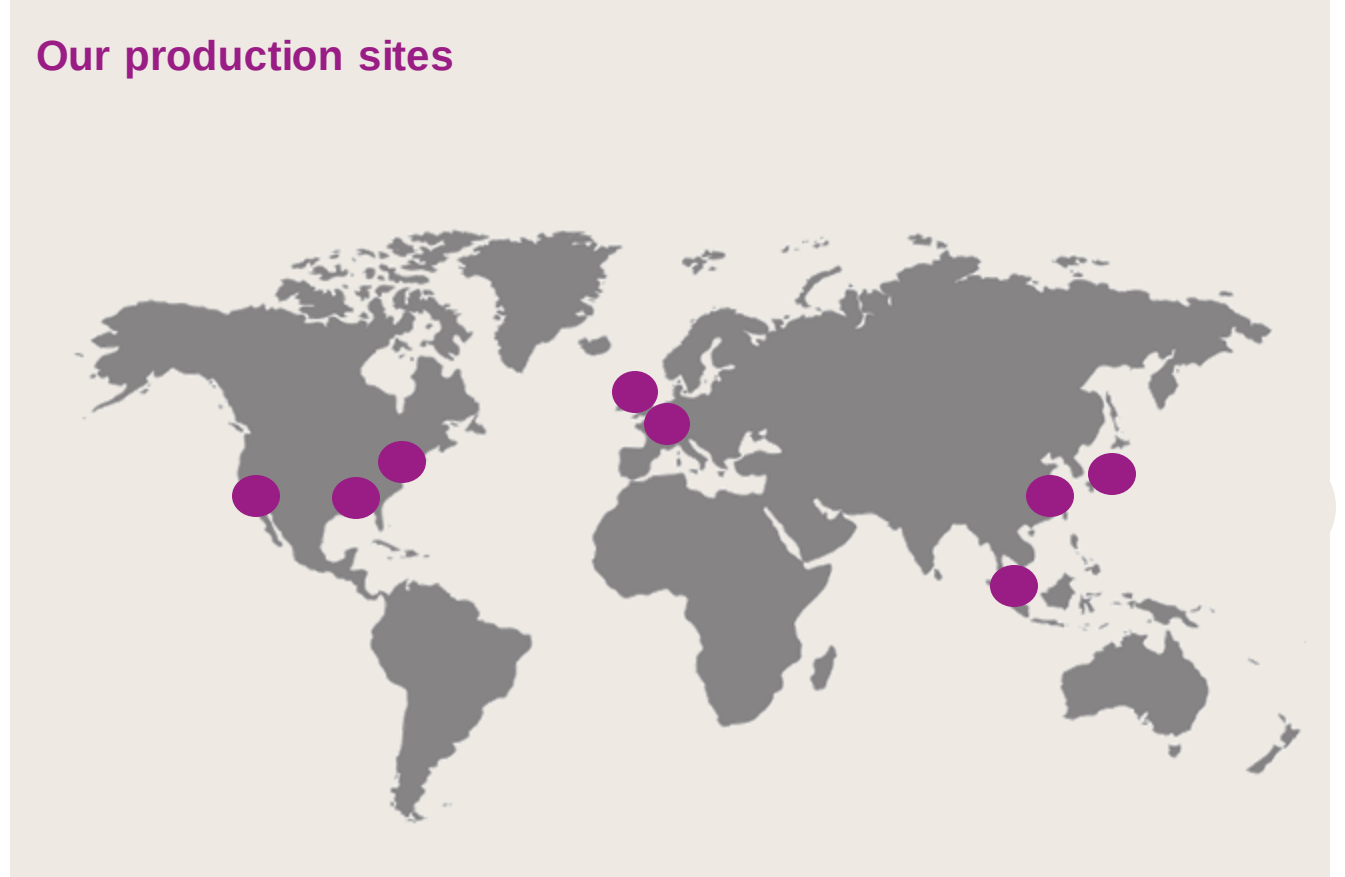
Epodil®
Ancamide®
Imicure®
Ancamine®
Anquamine®
Nourrybond®
Ancarez®
Amicure®

We are close to our customers – around the globe

Your Benefits

- Global presence of customer relevant functions
- Application know how for addressing specific regional needs
- Flexibility in responding to customer needs by leveraging global network
- Proximity to customers allows for fast response times

Our production sites



Evonik solves current challenges in the epoxy industry

Eco-friendly

- Low emissions
- Improved EH&S profile by elimination of harmful raw materials



Improved Productivity

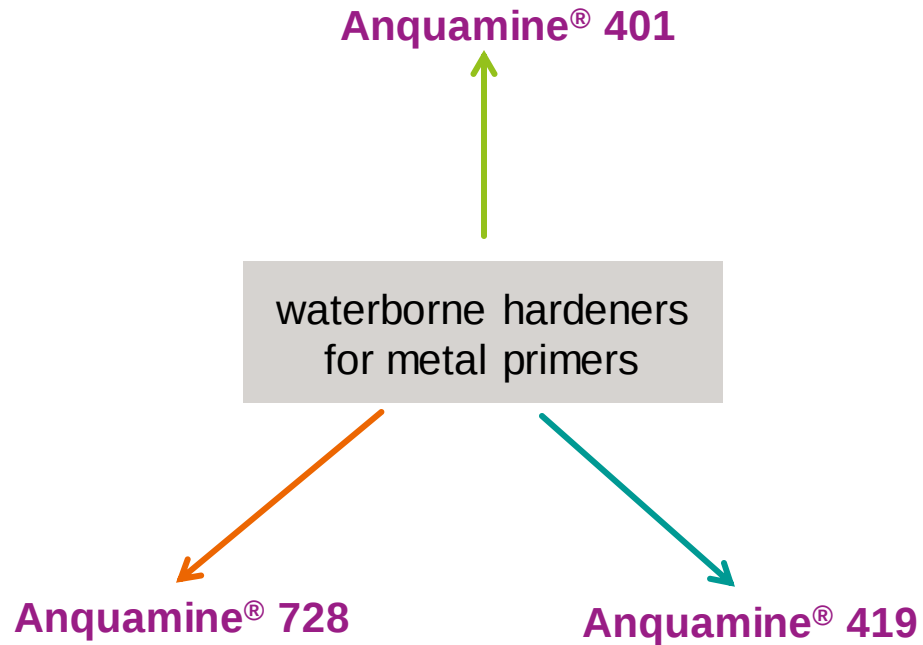
- Reduced downtime
- Wider application window / more robust conditions



Enhanced Performance

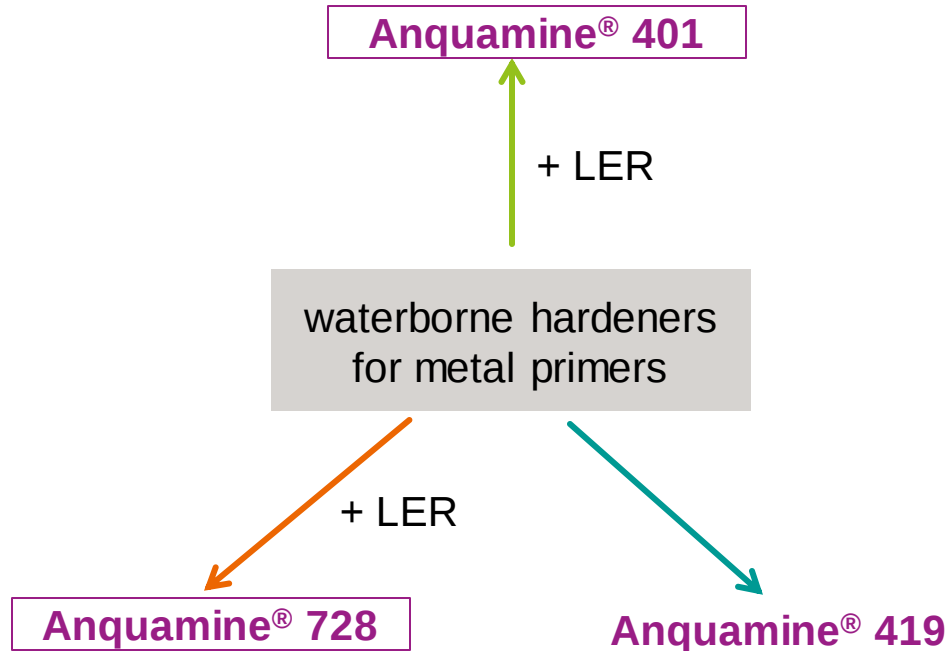
- High durability over time
- Long maintenance cycles

Anquamine® - Positioning of waterborne hardeners (1)



- Anquamine® products are water-based epoxy curing agents
- in a range of low or no VOC
- low color and good adhesion
- non-flammable and easy to apply and clean
- Excellent performance with solid epoxy resin, e.g. Ancarez® AR 555

Anquamine® - Positioning of waterborne hardeners (2)



- Anquamine® products are water-based epoxy curing agents
- in a range of low or no VOC
- low color and good adhesion
- non-flammable and easy to apply and clean
- Excellent performance with solid epoxy resin, e.g. Ancarez® AR 555
- Anquamine® 401 and 728 can be also formulated with liquid epoxy resin (LER)

Reactivity

Property	Anquamine® 401	Anquamine® 419	Anquamine® 728
viscosity @ RT [Pa*s]	25 - 40	8 - 10	5 - 15
dry to touch [h] *	1	1	1
TFST phase 3 [h:min] *	1:45	1:45	1:15
pot life [h]	1 - 1.5	4 - 6	1 - 2
carbamation after 24h Scale 1-5; 5 = best	4 - 5	4 - 5	5

*with 15min induction time

- low viscosity
- balanced reactivity
- long pot life (slow viscosity increase)
- very good carbamation resistance

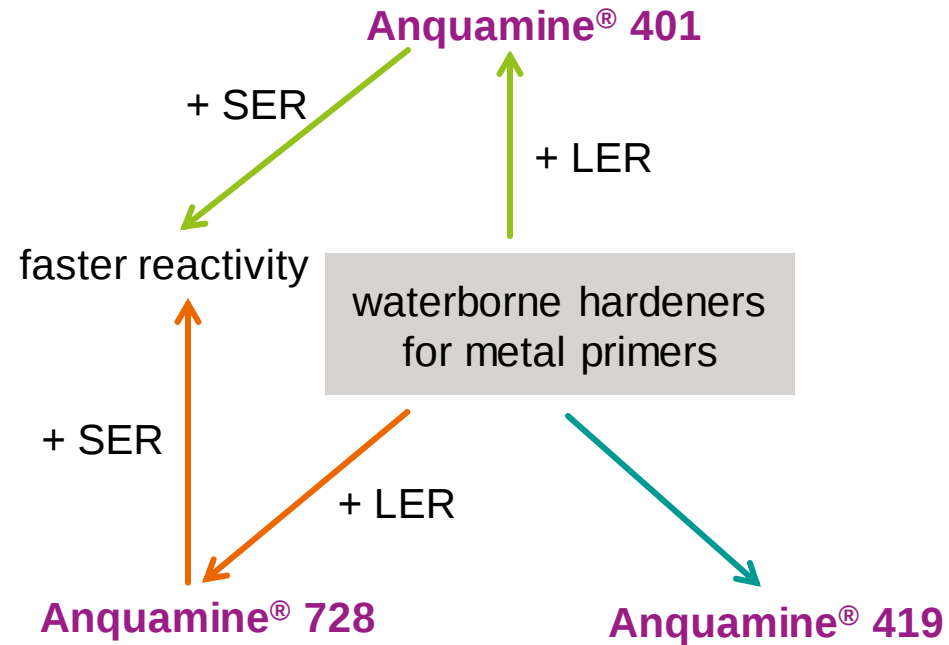
Reactivity increase with SER

Property	Anquamine® 728 + LER	Anquamine® 728 + SER
viscosity @ RT [mPa*s]	550 - 700	550 - 700
potlife @ RT [min]	50 - 60	30
TFST phase 3 [h:min] *	7:00	2:00
pendulum persoz 24h @ RT	60	200
pendulum persoz 7d @ RT	280	280
carbamation after 24h @ RT Scale 1-5; 5 = best	5	5

*with 15 min induction time

- higher reactivity with solid epoxy resin dispersion Ancarez® AR 555

Anquamine® - Positioning of waterborne hardeners (3)



- Anquamine® 401 and 728 can be also formulated with liquid epoxy resin (LER)
- increased performance with formulation of SER Ancarez® AR 555

Corrosion resistance by EIS test

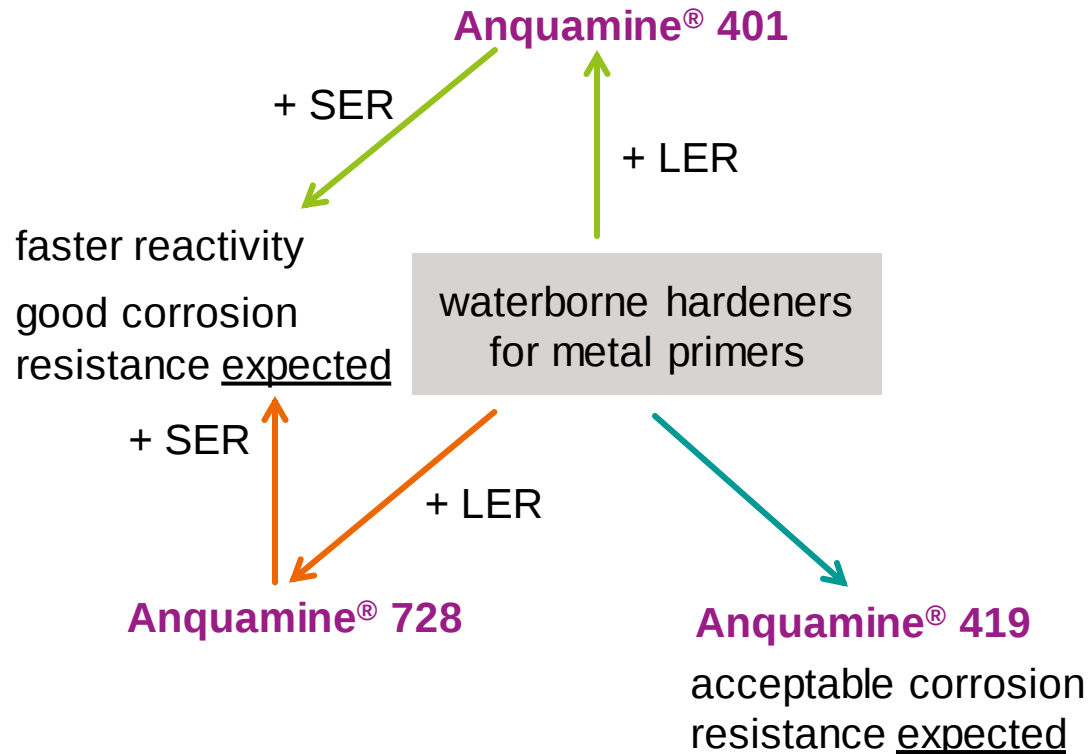
Property	Anquamine® 401	Anquamine® 419	Anquamine® 728
CPE Rp 1h	$9.7 \cdot 10^8$	$2.8 \cdot 10^8$	$4.9 \cdot 10^9$
CPE Rp 24h	$5.5 \cdot 10^7$	$4.4 \cdot 10^8$	$1.2 \cdot 10^9$



all examined in clear coat
1 : 1.6 epoxy excess Ancarez® AR 555

- **Electrochemical Impedance Spectroscopy**
- non-destructive: simulation to predict a long-term performance of protective coatings
- EIS tests show good results: for $R_p > 10^8$ a good corrosion resistance is expected (high barrier properties)

Anquamine® - Positioning of waterborne hardeners (4)



- increased performance with SER Ancarez® AR 555 → clearcoat formulation used for EIS tests
- EIS test showed good results, so testing is continued with corrosion resistance formulation → salt spray test

Guiding formulation for corrosion protection

Material	Function	g
Ancarez® AR555	SER	100
BAYFERROX® 130 M	pigment	20
Wollastocoat® 10 ES	filler	25
Heucophos® ZCP-PLUS	corrosion inhibitor	25
Blanc Fixe Micro®	filler	60
Lucenac 10MO	talcum	50
TEGO® DISPERS 750 W	wetting and dispersing additive	9
TEGO® Airex 901 W	dearator additive	5
SURFYNOL® 485 W	wetting agent for waterborne	5
TEGO® Viscoplus 3030	rheological additive	5
1-Methoxy-2-propanol	co-solvent	5
Water		93,5



Results from salt spray test

EIS – CPE Rp	Anquamine® 401	Anquamine® 419	Anquamine® 728
Clear Coat – 1 h // 24 h	$9.7 \cdot 10^8$ // $5.5 \cdot 10^7$	$2.8 \cdot 10^8$ // $4.4 \cdot 10^8$	$4.9 \cdot 10^9$ // $1.2 \cdot 10^9$
Protective Coat – 1 h // 24 h	$2.6 \cdot 10^8$ // $4.8 \cdot 10^9$	$4.4 \cdot 10^8$ // $1.2 \cdot 10^6$	$1.9 \cdot 10^8$ // $1.8 \cdot 10^9$

- Show similar results in tests with protective coat as in clear coat, BUT..
- results need to be taken carefully: the thick layer coating as well as all particles in the protective coating's formulation change the behaviour of capacitor, charge transfer, diffusion etc.

all examined

1 : 1.6 epoxy excess

Salt spray test – Anquamine® 401



START



500 h



750 h



1000 h

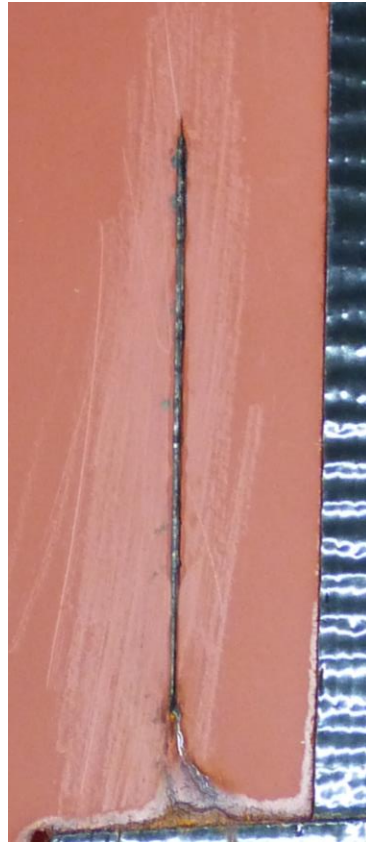


1250 h

Salt spray test – Anquamine® 419



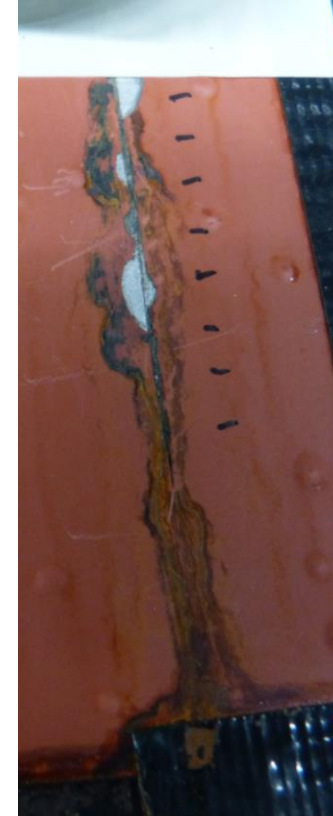
START



500 h



750 h



1000 h

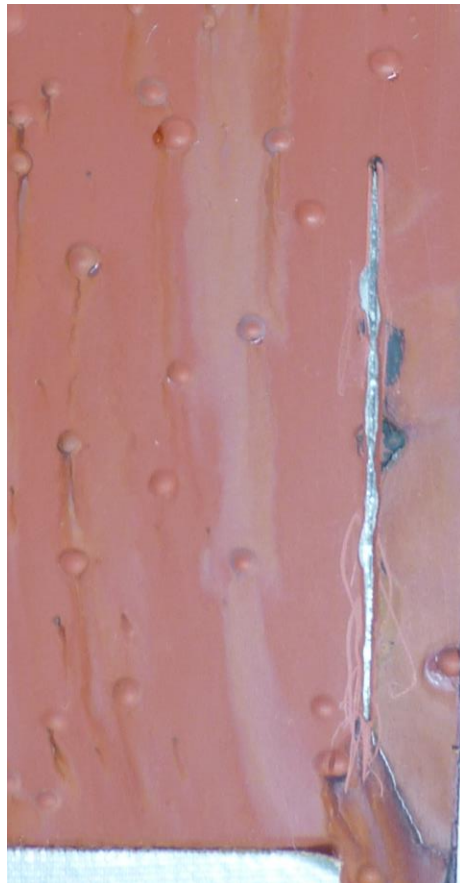


1250 h

Salt spray test – Anquamine® 728



START



500 h



750 h



1000 h



1250 h

Results from salt spray test

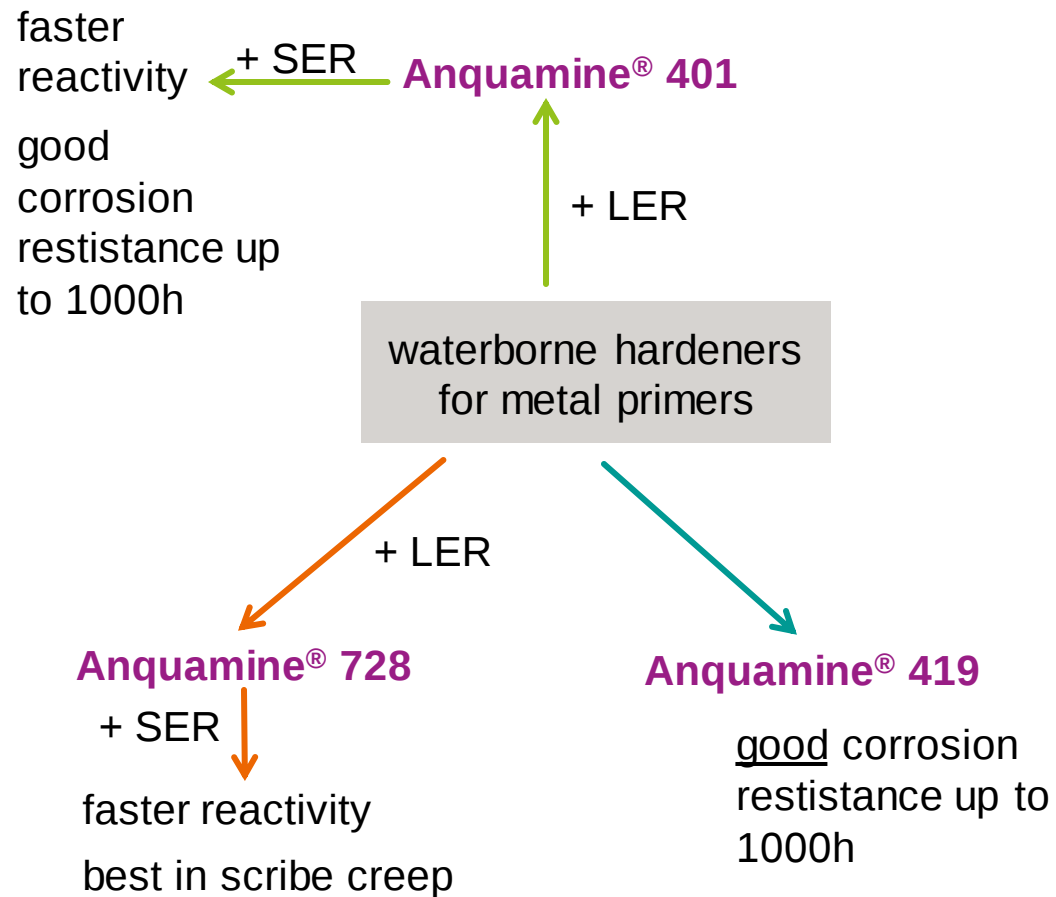
Scribe Creep (mean)	Anquamine® 401	Anquamine® 419	Anquamine® 728
500h	10	10	9,2
750h	9.5	8.6	8.7
1000h	8.4	7.2	7.8
1250h	3.8	5.7	7.2

Cross hatch scale 1 – 5: 5 = best	Anquamine® 401	Anquamine® 419
500h	4-5	4-5
750h	5	5

all examined in corrosion
protection formulation
1 ; 1,6 epoxy excess

- Anquamine® 401 and 419 with good corrosion resistance up to 1000h
- Anquamine® 728 with many blisters but good scribe creep
- If the surface showed too many defects, no cross hatch performed

Anquamine® - Positioning of waterborne hardeners (5)

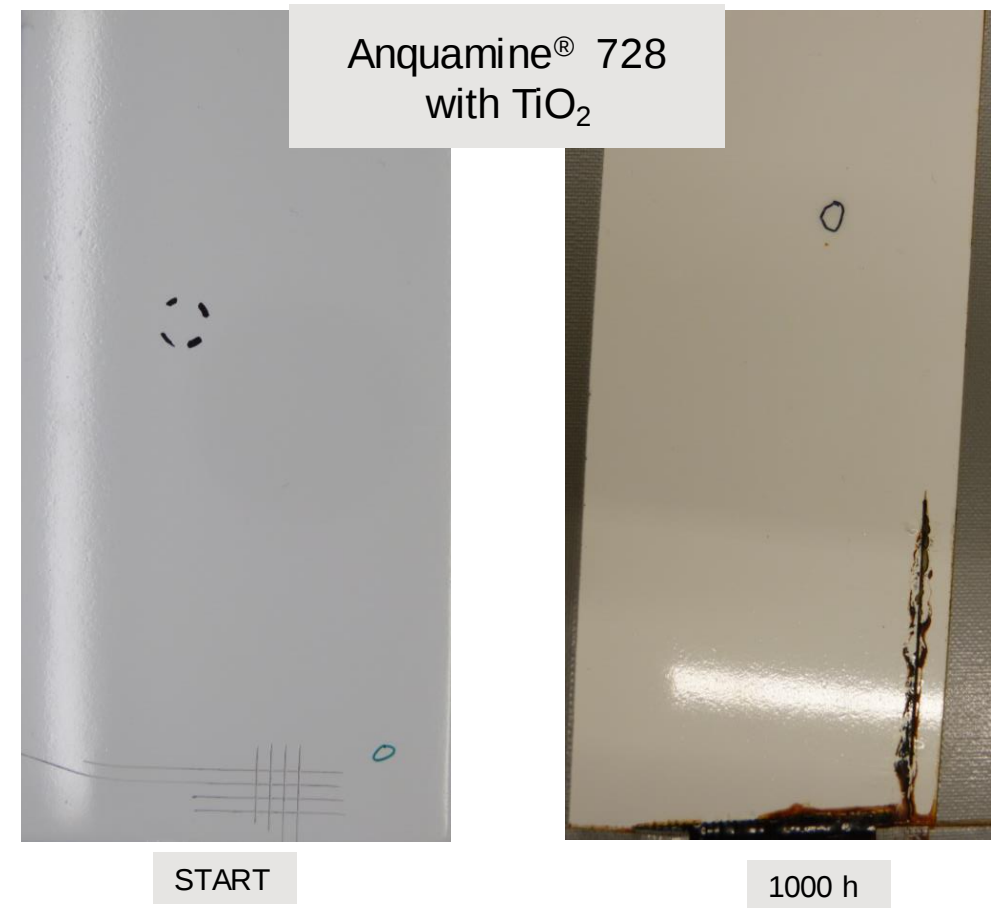
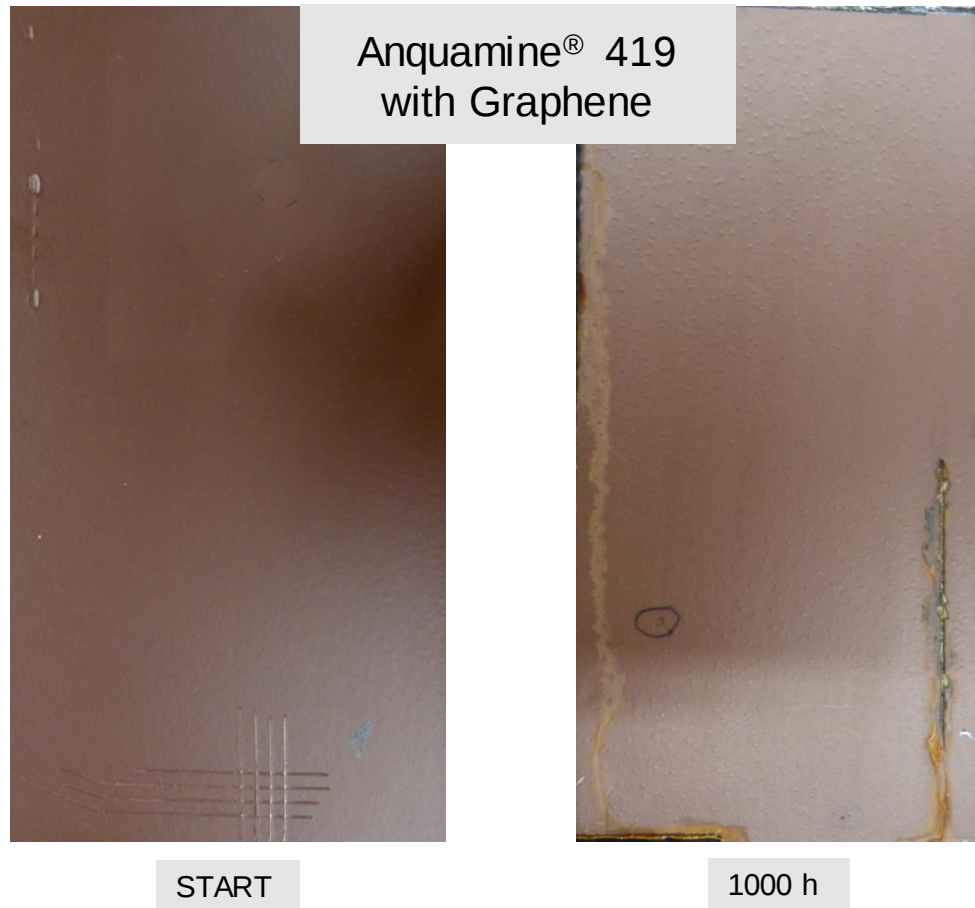


- acceptable corrosion resistance up to 500h can be correlated to C3
- good corrosion resistance up to 1000h can be correlated to C4
- optimization steps in formulation for blistering needed

Improved guiding formulations using TiO₂ as well as graphene

Material Name		Reference formulation	Graphene formulation	TiO ₂ formulation
Ancarez® AR555	SER	100	100	100
BAYFERROX® 130 M	pigment	20	16	-
Tiona® 568	pigment	-	-	16,9
Wollastocoat® 10 ES	filler	25	20	-
Heucophos® ZCP-PLUS	corrosion inhibitor	25	20	-
Blanc Fixe Micro®	filler	60	48	-
Lucenac 10MO	talcum	50	40	-
TEGO® DISPERS 750 W	wetting and	9	7,5	-
TEGO® DISPERS 755 W	dispersing additive	-	-	0,7
TEGO® Airex 901 W	dearator additive	5	5	0,2
SURFYNOL® 485 W	wetting agent for	5	5	-
TEGO® Wet 270	waterborne	-	-	0,5
TEGO® Viscoplus 3030	rheological additive	5	5	-
1-Methoxy-2-propanol	co-solvent	5	5	-
Graphene dispersion (30%)	corrosion inhibitor	-	12	-
Water		93,5	93,5	13

Panels after 1000h salt spray testing



Results from salt spray test – boosted formulations

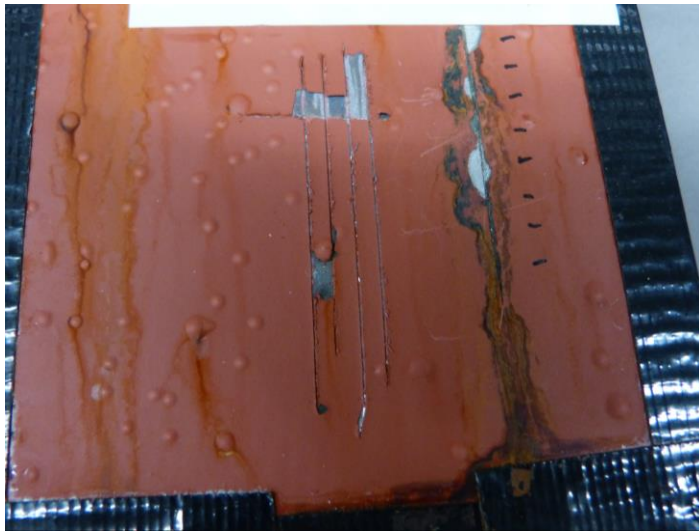
EIS – CPE Rp	Anquamine® 419	Anquamine® 728
Clear Coat – 1 h // 24 h	$9.7 \cdot 10^8$ // $5.5 \cdot 10^7$	$4,9 \cdot 10^9$ // $1,2 \cdot 10^6$
Anti-corrosive Formulation – 1 h // 24 h	$2.6 \cdot 10^8$ // $4.8 \cdot 10^9$	$1,9 \cdot 10^8$ // $1.8 \cdot 10^9$
Improved Formulation - 1h // 24 h	$6.9 \cdot 10^6$ // $4.2 \cdot 10^5$	$4.9 \cdot 10^9$ // $1.1 \cdot 10^9$

- Extended corrosion resistance with additives
- Significantly increased EIS test for Anquamine® 728 in TiO₂ formulation

all examined
1 : 1.6 epoxy excess

Results from salt spray test - blisters area and desity - boosted formulations

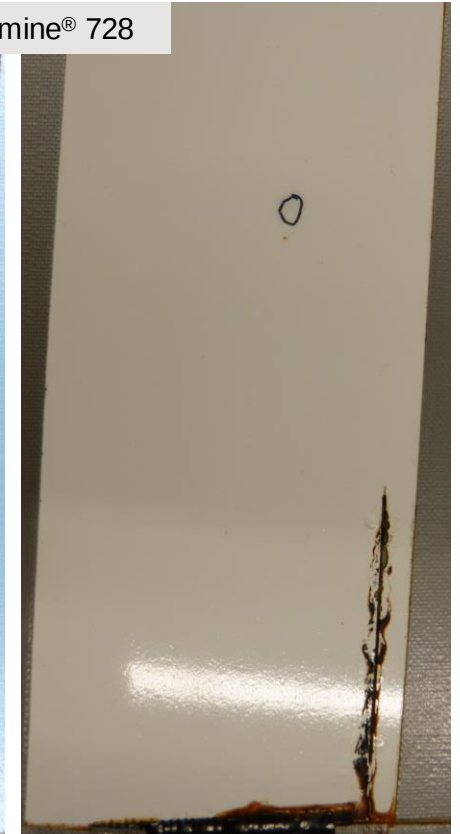
Anquamine® 419



all examined in corrosion
protection formulation
1 : 1.6 epoxy excess
after 1000h of salt spray test



Anquamine® 728



Salt spray test - boosted formulations

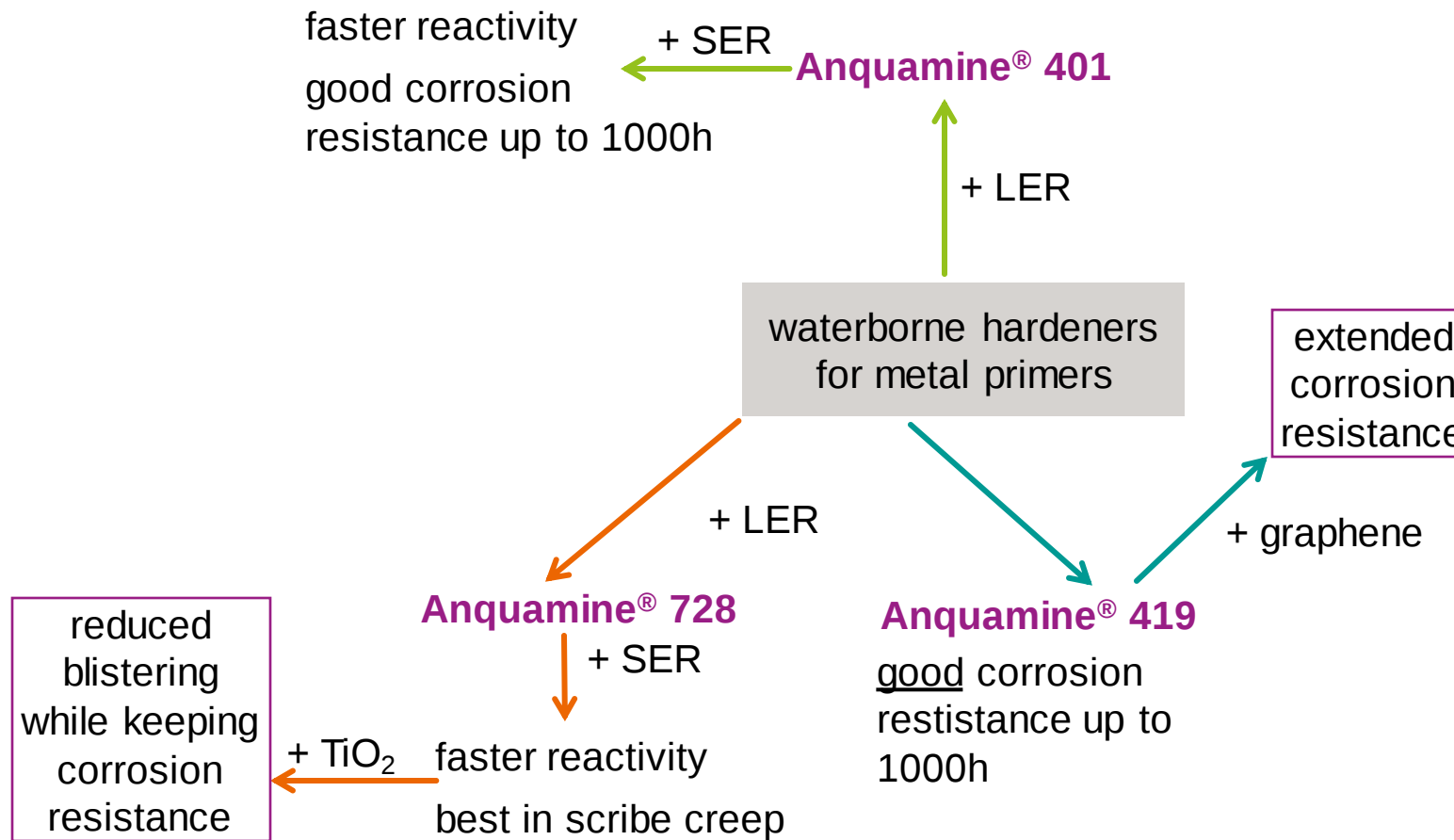
Scribe Creep (mean)	Anquamine® 419	Anquamine® 419 + 1,75% Graphene	Anquamine® 728	Anquamine® 728 + TiO ₂
500h	10	10	9.2	8.8
1000h	7.2	7.9	7.8	8.3

- Extended corrosion resistance with additives
- Additives help only to a certain level, otherwise decrease binder system leads to failure

all examined in corrosion
protection formulation

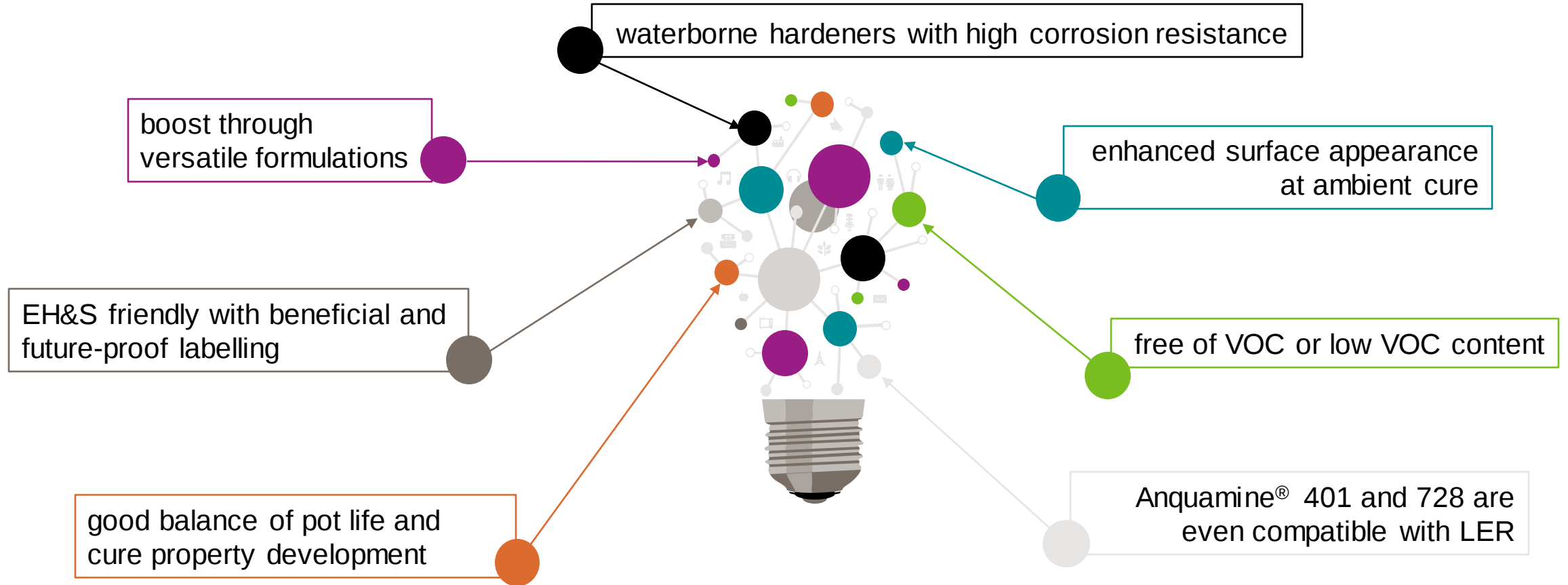
1 ; 1,6 epoxy excess

Anquamine® - Positioning of waterborne hardeners (5)



- Anquamine® hardeners can be formulated according to different application needs: filler, pigment, additives can be adjusted
- corrosion resistance can be extended up to a correlated C4 level

Anquamine® benefits for protective coatings



Contact us

Katharina Karns

Manager Applied Technology for Coatings

katharina.karns@evonik.com

Phone: +49 2365 49 7662

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Questions?





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