KING INDUSTRIES
SPECIALTY CHEMICALS

K-KAT®

Guide to Tin-Free Catalysts

For Urethane Coatings

K-KAT® catalysts are metal compounds designed for accelerating the crosslinking reaction of isocyanates with polyols. In addition to replacing tin catalysts, K-KAT catalysts offer a wide range of ***performance advantages.***

Benefits include an improved pot life/cure time relationship, less gassing in the presence of water (humidity), improved cold temperature cure response, catalysis of secondary hydroxyl groups, and ***excellent film properties.***

King Industries has established itself as a leader in manufacturing more environmentally acceptable additives for coatings, while also providing unique performance advantages. The K-KAT range includes aluminum, bismuth, zinc and zirconium catalysts.

A summary of the main attributes and properties of the K-KAT product line can be seen in the table below. Additional benefits can be found within the performance examples in the following pages.

Industry Leader in Tin Replacement Technology

Tin Alternatives

	Typical Attributes / Properties
Bismuth Carboxylate ***Recommended for 2K SB and 1K SB blocked isocyanate polyurethane coatings as well as ASE and foam***	• Properties comparable to tin catalysts • Excellent exterior durability • Non-yellowing • Excellent gloss retention • Catalyzes secondary hydroxyl groups
Bismuth Complex ***Recommended for 1K SB blocked isocyanate coatings, E-Coat coatings and foam***	• Best-in-class efficiency for fast cure with low dosage • Excellent hydrolytic stability for a bismuth catalyst • Outstanding low-temperature activity
Zirconium Chelate ***Recommended for 2K SB, WB and high solids polyurethane coatings as well as ASE systems and foam***	• Fast cure and selective catalysis (less gassing) • Effective in cold and humid conditions • Excellent exterior durability • Good pot life with 2,4-Pentanedione
Aluminum Chelate ***Recommended for 2K SB polyurethane coatings***	• Extends pot life better than tin with 2,4-Pentanedione • Synergistic effects with pot life extenders • Excellent exterior durability
Zinc Carboxylate ***Recommended for 2K polyurethane and 1K blocked isocyanate polyurethane coatings as well as ASE systems and foam***	• Hydrolytically stable • FDA 175.300 compliant • Sustained back-end activity
Zinc Complex ***Recommended for 2K WB and SB polyurethane coatings, 1K blocked isocyanate polyurethane coatings, and ASE systems***	• Excellent hydrolytic stability • Latent activity • Good versatility

K-KAT ® - Core and Next Generation Tin Alternatives

	SB 2K PU	WB 2K PU	1K PU Blocked NCO	1K Moisture Cure PU	100% NV 2K PU
Products	K-KAT XK-651 K-KAT XK-682 K-KAT XK-635 K-KAT 4205 K-KAT 6212 K-KAT 5218	K-KAT XK-661 K-KAT 6212	K-KAT XK-651 K-KAT XK-682 K-KAT XC-B221 K-KAT XK-626 K-KAT XK-672 K-KAT XK-635	K-KAT XK-661	K-KAT 348 K-KAT XK-604 K-KAT XK-664 K-KAT XK-651 K-KAT XK-672
Applications	Automotive exterior General industrial Floor coatings Aerospace	Automotive interior Maintenance Floor coatings Aero interior	Coil coatings Packaging General industrial Ink	Sealants Floor coatings Binders Adhesives	Cast elastomers Adhesives Floor coatings Potting

Performance Advantages

◯ Good ◒ Very Good ● Excellent — Not Recommended

	K-KAT Product	Use % (TRS)	Attributes	Hydrolytically stable	Back-end active	Front-end active	Latent (extends pot life)	Efficient (low dosage)	Selective (less gassing)	Low temp. active
BISMUTH	XK-651	0.1 - 2.5	Bi-carboxylate with proprietary hydrophobic ligand technology for superior hydrolytic stability vs conventional Bi-carboxylates	◒	◯	●	—	●	◒	●
	XK-682	0.1 - 1.5	Bi-amine complex with outstanding combination of hydrolytic stability with high efficiency due to metal-amine synergy	◒	◒	●	—	●	◯	●
ZIRCONIUM	6212	0.3 - 2.0	Zr-chelate with exceptional selectivity, effective in extreme cold and/or humid conditions, also useful for prepolymer synthesis	—	◯	◒	◯	◒	●	●
	4205	1.0 - 2.0	Zr-chelate with ability to extend pot life (latent activity) and excellent selectivity	◯	◯	—	●	◯	●	◒
ALUMINUM	5218	1.0 - 2.0	Al-chelate that provides best balance of fast dry time with long pot life when used with 2,4-pentanedione*	◯	◒	◯	●	◯	◒	◯
ZINC	XK-661	0.2 - 1.0	Zn-amine complex with exceptional hydrolytic stability, effective in WB 2K PU, also useful in 1K moisture cure urethanes	●	●	◯	◒	◯	◯	◯
	XK-635	0.1 - 1.0	Zn-based catalyst with excellent overall balance of performance, especially effective for Sn-replacement with MEKO-blocked NCO	●	●	◯	◒	—	◯	◯
MIXED METALS	XK-672	0.1 - 1.0	Effective for Sn-replacement in 1K PU blocked NCO, meets requirements of FDA 21 CFR 175.300	●	●	◯	◒	◯	◒	◯
	XK-604	0.1 - 0.5	Formulated mixed metal-carboxylate with latent activity in 100% NV 2K PU, especially for Hg-replacement in aliphatic elastomers	◒	◒	◯	◒	◯	◒	◒
	XK-626	0.1 - 1.0	Effective in 1K PU blocked NCO, meets requirements of FDA 21 CFR 175.300	●	●	◯	◒	◯	◒	◒
	XK-664	0.1 - 0.5	Balanced blend of Bi for front-end initiation + Zn for delayed back-end cure, improved hydrolytic stability and surface cure	◒	◒	◯	◒	◯	◒	◒

*When using with 2,4 pentanedione, add the 2,4 PD first with agitation, then add K KAT 5218, typically dosed at 1:1 ratio with 2,4 PD

K-KAT® XK-651 vs. Competitive Bismuth

K-KAT XK-651 is a novel bismuth carboxylate that exhibits improved hydrolytic stability compared to other bismuth carboxylate catalysts. The study below shows the excellent stability of K-KAT XK-651 when water is present in the formula.

2K PU Hydrolytic Stability Study

Conditions	Polyol spiked with 0.1% water
Metal Levels	Competitor Bismuth = 0.2% Bi on TRS ***K-KAT XK-651*** = 0.2% Bi on TRS

After 24 hours

K-KAT XK-651 — ***Clear***

Competitor Bismuth — ***Hazy***

The pictures to the right demonstrate the outstanding hydrolytic stability of K-KAT XK-651 when compared to a competitor's bismuth carboxylate at 1 day and 30 days of ambient storage.

After 30 days

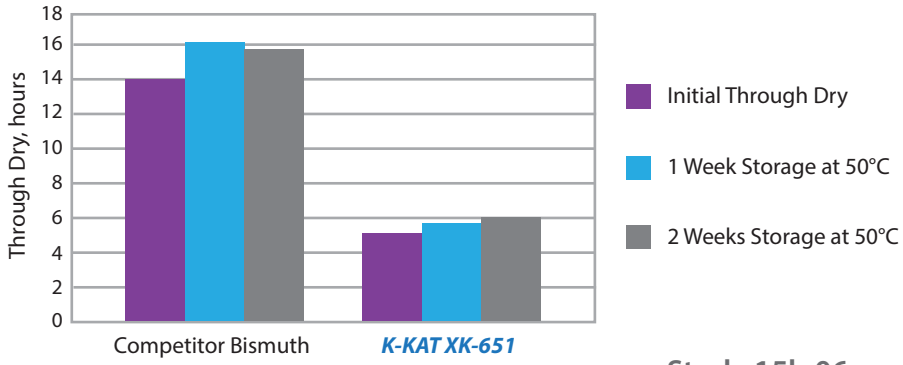
K-KAT XK-651 — ***Clear***

Competitor Bismuth — ***Settling***

Formulators Note

K-KAT XK-651 combines superior hydrolytic stability with more efficient catalysis, achieving faster dry times with less reactivity drift on aging. K-KAT XK-651 is the preferred bismuth catalyst for conditions in which moisture may be present.

Through Dry - ***K-KAT XK-651*** vs. Comp. Bi



Study 15k-06

Pot life and gloss vs. DBTDL - 2K WB

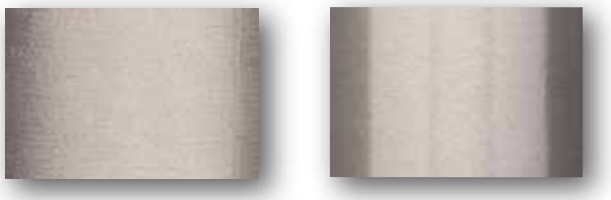
K-KAT XK-661 is a novel non-tin catalyst recommended for 2K waterborne coatings. It has excellent hydrolytic stability, which improves gloss retention and exterior durability. K-KAT XK-661 delivers superior pot life and gloss retention vs. tin, as seen in the study below where panels were coated with aged paint.

2K Waterbased Acrylic Isocyanate Clear Coat

Substrate:	Bonderite 1000
Cure:	30 minutes @ 80°C + 1 week ambient
Catalyst Levels:	DBTDL = 0.04% on TRS ***K-KAT XK-661*** = 0.06% on TRS
Dry film thickness:	0.7 mil

Better Pot Life Stability = Better Gloss Retention

Gloss of panels coated with aged paint



2 hours with DBTDL

Loss of Gloss

Gloss 60° = 30.3

3 hours with K-KAT XK-661

Retains Gloss

Gloss 60° = 95.8

Study 15k-12

FDA Approvable Catalyst

K-KAT® XK-672 is an effective catalyst for the reaction of isocyanates and polyols for the production of urethane coatings. It also meets FDA 21 CFR 175.300 requirements.

The following study is designed to demonstrate typical properties of tin-free catalysis in a 1K blocked isocyanate system. Improved pendulum hardness and MEK resistance can be seen in the results below.

K-KAT XK-672 is ***FDA approvable*** and compatible with FDA approvable resins and coatings systems.

Joncryl 500 / MEKO Blocked NCO

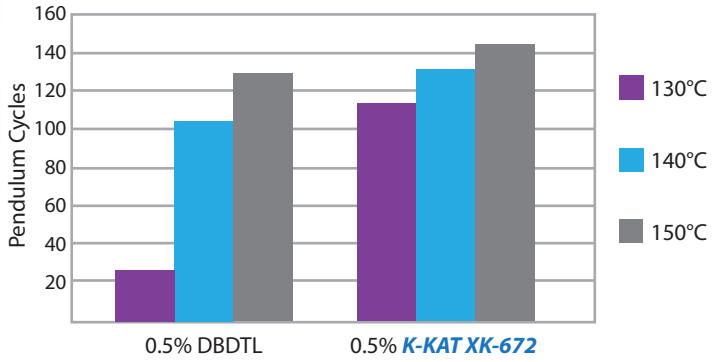
Substrate:	Bonderite 1000
Cure:	20 Min. Bake @ 130°C, 140°C, 150°C
Catalyst Levels:	DBTDL = 0.5% on TRS ***K-KAT XK-672*** = 0.5% on TRS
Dry film thickness:	1 mil

1K Blocked NCO System

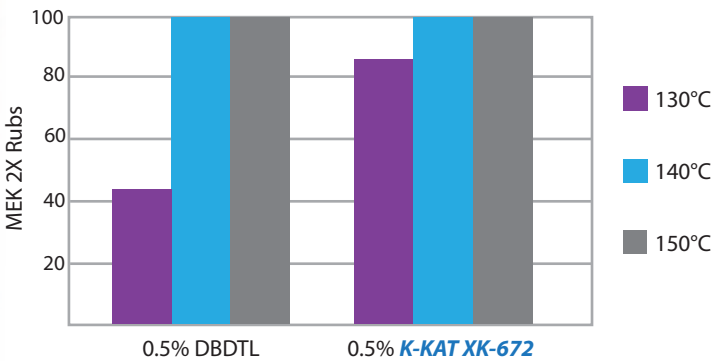
Materials	Description	Acrylic Control	*Tin-FREE K-KAT*
Joncryl[1] 500	Acrylic Polyol	45.74	45.74
K-KAT XK-672	***Tin-FREE Catalyst***	-	***0.32***
DBTDL	Tin Catalyst	0.32	-
PM Acetate	Solvent	9.35	9.35
Aromatic 150	Solvent	3.88	3.88
Isopropanol	Solvent	2.89	2.89
DISPARLON® L-1984	Leveling Agent	0.29	0.29
Trixene[2] 7984	Blocked Isocyanate	37.54	37.54
Total		100	100

NCO: OH = 1:1

Pendulum Hardness - ***K-KAT XK-672*** vs. DBTDL



MEK Resistance - ***K-KAT XK-672*** vs. DBTDL



Study 16k--04

Although the catalyst is a minor formulation component in most systems, it contributes significantly to performance. The K-KAT product line offers a range of catalysts for a variety of applications. Below is a table to guide you to the best product selection based on your sytems type.

		Coatings				ASE			Resin	Foam	
	Product	2K PU WB	2K PU SB	1K PU Blocked NCO	E-Coat	1K PU Moisture Cure	Poly Siloxane	100% NV PU Cast Elast.	Prepol. Synth.	Flex Molded	Rigid HFO
BISMUTH	XK-651		●				●			●	●
	XK-682			●	●						●
	348								●		
	XC-B221				●				●		
ZIRCONIUM	6212	●	●						●		
	A209	●							●		
	4205		●								
ALUM.	5218		●								
ZINC	XK-661	●				●					
	XK-635		●	●							
	XK-614	●				●		●		●	●
	XK-633									●	
MIXED METALS	XK-604							●			
	XK-664							●		●	●
	XK-618							●			
	XK-626			●				●			
	XK-672			●				●			
OTHER	XK-665							●			
	670*						●				
	XK-678						●				
	XK-620				●						

*K-KAT 670 performance can be enhanced synergistically with the addition of an equal dose of 3-aminopropyltriethoxysilane adhesion promoter

Notes:

Trademark References

1. Joncryl	BASF
2. Trixene	LANXESS

Contact Information

www.kingindustries.com

Global Headquarters
Tech. Service, R&D, and Sales
King Industries, Inc.
1 Science Rd.
Norwalk, CT 06852, USA
Phone: 1-203-866-5551

European Tech. Sales Office
King Industries, International
Science Park 402
1098 XH Amsterdam
The Netherlands
Phone: 31 20 723 1970

Asia-Pacific Tech. Sales Office
Synlico Tech Co., Ltd.
42 Ju Lin Ya Yuan
RichMond Hill (Juhaoyuan)
Zhongshan, China
Phone: 86 760 88229866