PATCHAM

METAL-BASED CATALYSTS FOR POLYURETHANES

A Sustainable Approach to Technology

Patcham FZC is a global manufacturer of specialty additives headquartered in the United Arab Emirates. Since its inception, Patcham has steadily grown to become a leading supplier of metal carboxylates and specialty additives for Paint & Coatings, Inks, PVC, Composites and Polyurethane. We also manufacture a range of tin based and tin free catalysts for various end use industries.

The company's Pat-Add range of coating additives includes driers, wetting & dispersing agents, defoamers, slip & leveling agents, rheology modifiers. All our products are APEO free and many are produced from green raw materials. Several are designed to enable our customers to make products that are low VOC or VOC free.

Patcham has a strong manufacturing and R&D infrastructure that enables rapid transition from concept to products. The company has strategically located technical service laboratories, offices and representatives around the world to provide efficient customer service. In addition, a well-developed robust supply chain network enables us to deliver our products and services to customers around the globe with minimal lead-time.

General Information

Polyurethanes (PU) are one of the most versatile plastic materials.

There are several chemical reactions that occur in the formation of Polyurethane PU and Polyisocyanurate PIR products that require the assistance of catalysts.

Blow reaction is important for many foams but produces unwanted gassing in other systems.
Gel reaction is the defining reaction for all urethanes.
Trimerization is required for the production of rigid foams.

These reactions occur readily at temperatures above 110ºC. However, at room temperature without a catalyst, they are slow, taking days.

	Isocyanate reaction with	
FAST	water	blow reaction
MEDIUM	polyols	gel reaction
SLOW	isocyanate	polymerization of which Trimerization is the most important

Catalysts exert a considerable influence on PU structures and its end properties by changing the relative rate of these primary chemical reactions.

Catalysts have a tendency to catalyze several of these reactions at once, although to differing degrees, and their individual action can be highly temperature and time dependent.

A mix of catalysts is often required to achieve a critical balance between these reactions in order to achieve the desired end product properties and workability.

Additions of metal-containing catalysts, in concentrations that can be measured in ppm, have a profound effect on the rate of reactions and can produce synergy with tertiary amine catalysts.

Catalyst deactivation can be a function of water content in the PU system and thus hydrolytic stability of the catalyst is also an important formulating consideration.

PU/PIR Catalysts are mainly tertiary amines and metal-containing compounds

Principal Reactions		Product	Amines	Metal-Based Catalysts
Blow reaction	NCO/H2O Isocyanate/water	Urea + CO_2	Strong	Weak
Gel reaction	NCO/OH Isocyanate/polyol	Polyurethane	Strong	Very Strong
Trimerization	NCO/NCO Isocyanate/isocyanate	Polyisocyanurate	Weak	Very Strong

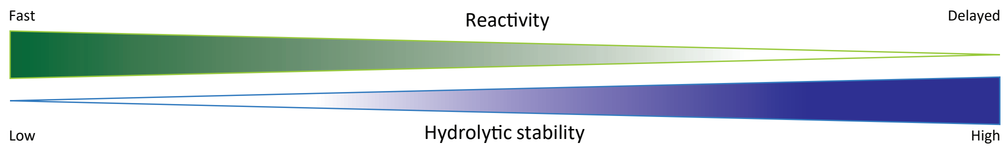
Metal based catalysts are far more desirable than amines

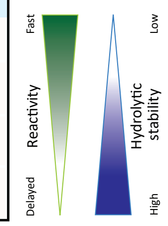
Amines	Metal-Based Catalysts
Bad smell	Low odor
Corrosive	Non-corrosive
High pH	Neutral
Toxicity issues	Many have very low toxicity
Instability with acid treated pigents	Non-reactive towards acid treated pigments
Deactivation of HFO blowing agents	Stable with HFO blowing agents
Low Flash Point	Many have high flash point
End product discoloration	Several have very low color

Tin Based Catalysts

Tin based gel catalysts cover a rage of activity from Fast Acting to Delayed Action and varying degrees of hydrolytic stability.

PATcat		Di-acetate	Octoate	Di-neodecanoate	Di - (2-ethylhexyl malate)	Di-laurate	Pentane dionate	Di-(lauryl mercaptide)	Di-(2 ethylhexyl thioglycolate)	Thioglyceride
Tin +4	Mono butyl		3017							
	Dimethyl			3028				3027	3030	
	Dibutyl	3003		3004	3025	3001/3020	3006	3014	3026/3046	3031
	Dioctyl	3023		3024		3005	3016	3029	3022	





Generally tin catalysts that demonstrate delayed action tend to have better hydrolytic stability.

PATcat Tin Catalyst		
PATcat 3017	Monobutyltin trioctoate	19.0%
PATcat 3028	Dimethyltin dineodecanoate	23.5%
PATcat 3027	Dimethyltin dilauryl mercaptide	20.5t%
PATcat 3030	Dimethyltin di (2-ethylhexyl thioglycolate)	19.0%
PATcat 3003	Dibutyltin diacetate	33.0%
PATcat 3004	Dibutyltin dineodecanoate	20.0%
PATcat 3001	Dibutyltin dilaurate	18.0%
PATcat 3020	Dibutyltin dilaurate (lower crystallization temperature)	18.0%
PATcat 3014	Dibutyltin lauryl mercaptide	18.0%
PATcat 3026	Dibutyltin di (2-ethylhexyl thioglycolate)	18.0%
PATcat 3046	Dibutyltin di (2-ethylhexyl thioglycolate)	2.0%
PATcat 3025	Dibutyltin di (2- ethylhexyl maleate)	17.0%
PATcat 3006	Dibutyltin acetyl acetonate	27.0%
PATcat 3018WB	Dibutyltin dilaurate	1.8%
PATcat 3031	Dibutyltin thioglyceride	26.5%
PATcat 3023	Dioctyltin diacetate	26.0%
PATcat 3024	Dioctyltin dineodecanoate	17.0%
PATcat 3005	Dioctyltin dilaurate	16.0%
PATcat 3022	Dioctyltin di (2-ethylhexyl thioglycolate)	15.0%
PATcat 3029	Dioctyltin di (lauryl mercaptide)	15.5%
PATcat 3016	Dioctyltin acetyl acetonate	21.0%

Trimerization Catalysts for PIR Applications

Trimerization reaction in the PIR industry is essential for the formation of rigid closed cell structures that impart dimensional strength and improved insulation properties to the end products.

PATcat 5000 series catalysts can be used as the sole catalyst in PIR systems.

They provide catalysis for the Blow, Gel and Timeization reactions.

Variations in system formulations and production equipment place different demands on the catalyst such as viscosity, OH and water content.

Trimerization is normally the slowest of the isocyanate reactions and requires catalysts to increase the rate of production and yield of trimerized material:

Patcham produces a wide range of amine free trimerization catalysts to meet those needs:

Metal	Anion	Carrier Diluent*	Catalyst strength Metal content %wt/wt**	Water content+	Typical OH value	Typical viscosity++ (Cp) at 25°C	PATcat
Potassium	Octoate	DEG	15.0	5.0% max	525	3500	5001
			15.0	3.5% max	460	7000	5003
			10.0	2.0% - 4.0%	700	1200	5011
		MEG	15.3	3.0% - 4.0%	660	3500	5016
			15.0	9.5% - 10.5%	965	550	5012
	Acetate	DEG	15.0	5.5% max	910	350	5005
			13.2	2.0% max	815	350	5008
			10.0	5.5% max	1060	150	5004
		MEG	18.0	3.0% - 4.0%	1130	200	5018
			15.3	1.0% max	1100	150	5019
			15.0	3.0% - 5.0%	1290	75	5007
			13.0	2.7% - 3.5%	1340	100	5013
			10.0	3.0% - 5.0%	1530	50	5006
	Neodecanoate	DEG	10.0	3.0% - 5.0%	700	3500	5010
	Propionate	MEG	14.0	4.0%-5.0%	980	120	5020

Smooth Rise Profile Catalyst						
Mixture			3.0% - 5.0%	790	250	5022

Economical Potassium Octoate 15 % Alternative						
Mixture			2.0% - 4.0%	820	250	5101

* DEG gives lower OH values (less unwanted consumption of isocyanate). MEG gives lower viscosity for ease of handling.
** Higher metal content affords lower dosage and better economy.
+ Higher water content gives lower viscosity for ease of handling but increases the OH value.
++ Lower Viscosity improves ease of handling.

PATcat 4202
Tin-Free Replacement for Stannous Octoate in PU Foams

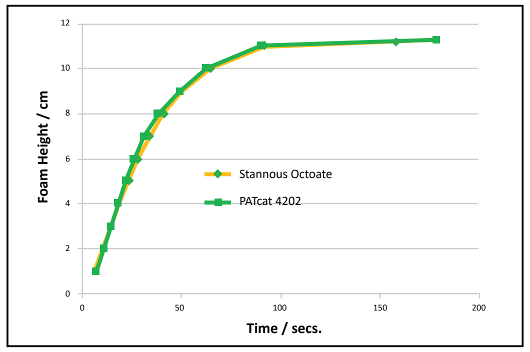
Stannous octoate is commonly used along with tertiary amines in the production of PU foams.

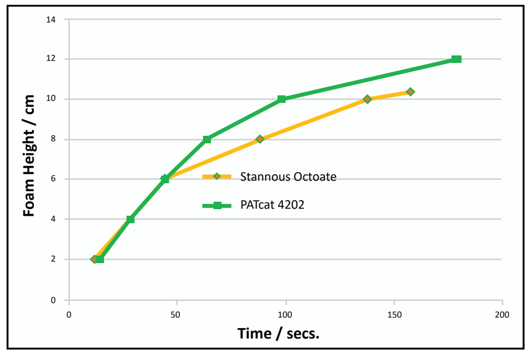
Stannous Octoate	PATcat 4202
► Tin has toxicity issues	► Tin - free
► Contains Octoate (2 Ethyl Hexanoic Acid)	► 2 Ethyl Hexoic acid – free
► Poor Hydrolytic Stability	► Good Hydrolytic Stability
► Cold Flow problems	► Very little shrinkage

Performance test results in Flexible and High Resilience Foam

Flexible Foam	Stannous Octoate	PATcat 4202
Polyol 3000	100.0	100.0
33LV	0.3	0.3
Silicon surfactant	1.1	1.1
Water	4.5	4.5
Stannous Octoate	0.2	
PATcat 4202		0.4
TDI (Index 114)	59.9	59.9
Top of the cup (sec)	44	42
Rise time (sec)	115	113
Foam height (cm)	16.9	17
Tack free (Hr:Min)	2:00	1:45
Peak exotherm temp °C	52.4	51.4
Remarks	Shrinkage	

HR Foam	Stannous Octoate	PATcat 4202
Polyol for HR Foam	100.0	100.0
Water	2.77	2.77
Cross linker	2.90	2.90
Surfactant	1.10	1.10
Tertiary amine catalyst	0.12	0.12
Stannous Octoate	0.04	
PATcat 4202		0.08
TDI (Index 105)	33.00	33.00
Top of the cup (sec)	58	58
Rise time (sec)	142	143
Foam height (cm)	14.6	14.9
Tack free (Hr:Min)	1:30	1:30
Peak exotherm temp °C	52.8	53.3





Stannous Octoate **PATcat 4202**

Stannous Octoate **PATcat 4202**

PATcat 4202 better performance and without the detriments.

Patcham produces tin and tin-free catalysts for PU spray foams based on various blowing agents including HFOs

Patcham Tin Catalysts

PATcat		Di-acetate	Octoate	Di-neodeca-noate	Di-(2-ethyl-hexylma-late)	Di-laurate	Acetyl acetonate	Di-(lauryl mercaptide)	Di-(2 ethyl-hexylthioglyco-late)	Thioglycerol
Tin+4	Mono butyl		3017							
	Dimethyl			3028				3027	3030	
	Dibutyl	3003		3004	3025	3001/ 3020	3006	3014	3026/ 3046	3031
	Dioctyl	3023		3024		3005	3016	3029	3022	

PATcham Tin-Free catalysts for PU Spray Foam:

Enhanced Bismuth Catalyst	Typical Dosage
PATcat 4012	**0.5**
PATcat 4020	**0.75**
PATcat 4009	**1.0**
PATcat 4031	**1.5**

• Improved Hydrolytic Stability
• Improved shelf stability with HFO blowing agents

Straight Bismuth catalysts tend to have poor hydrolytic stability and produce spray foams with shorter shelf life.

Patcham Enhanced Bismuth Catalysts have improved hydrolytic stability and produce spray foams with longer shelf stability.

Catalysts for CASE Urethane systems

Patcham produces a range of metal based catalysts for CASE urethane systems.

Unlike amine catalysts most metal based catalysts do not strongly promote the reaction between isocyanate and water (blow reaction, generating CO_2) and thus are less likely to create microfoam, pinholes and other surface defects.

Polyurethane CASE systems can be two component (2K) or one component (1K), both of which can be solvent-based or waterborne and may or may not require heat for curing.

Selection of catalysts depends primarily on the curing chemistry and secondly on processing requirements:

Solvent based & 100% solids 2K and 1K Urethanes	Waterborne 2K and 1K Urethanes curing:
2K Urethane curing: Solvent evaporation followed by urethane cross-linking (gel reaction) requiring catalysts. **1K Urethane curing:** Oil modified Urethanes cure by auto-oxidation – see **Patcham Paint Driers** for more information about catalysts (driers) for these alkyd containing coatings. **Moisture-cured** (Urethane reactions initiated by water followed by gelling) or **blocked isocyanates** (require heat to unblock them so they can react with polyols) these systems require catalyst to accelerate curing.	Water soaking into the substrate or evaporating followed by cross-linking (gel reaction) requiring catalysts. May also require the application of heat. **Oil modified PUDs** cure by auto-oxidation – see **Patcham Paint Driers** for more information about catalysts (water dispersible driers) for these alkyd containing systems.
2K systems often require catalysts that can provide longer pot life (delayed action).	**Require catalysts that demonstrate a degree of hydrolytic stability**

Polyurethane Coatings requiring urethane catalysts						
			Catalysts Requirements	Tin-based typically	Tin-free Typically	
1K	organic solvent based	Heat Cured	Fast Acting catalyst	DBTDL	Bismuth	4005, 4006, 4007
1K	organic solvent based	Moisture Cure	Fast Acting catalyst	DBTDL		
1K	water-based	Heat Cured	Fast Acting catalyst/ Hydrolytically stable		Bismuth	4009, 4012, 4031
2K	organic solvent based	Ambient	Delayed action	Tin mercaptides or thiogltycolates	Mix metals	4009, 9001, 19060
2K	water-based	Ambient/ Heat cured	Fast Acting catalyst/ Hydrolytically stable		Bismuth	4009, 4012, 4031
Other PU coatings requiring catalysts						
1K	Urethane Alkyds	Ambient/ Heat cured	Autoxidation catalyst Alkyd paint dires		Co, Zr, Ca	Alkyd Paint Driers

PATcat	
4005	Economical
4006	General Purpose Tine-Free
4007	2EHA-Free
4009	Mixed Metal
4012	Hydrolytically Stable
4031	Imparts improved shelf life
9001	Concentrated Zinc-Based
19060	Non-Toxic / Most Delayed Action

TIN CATALYSTS

Solvent based and water based

PATcat Tin Catalyst	
PATcat 3017	Monobutyltin trioctoate
PATcat 3028	Dimethyltin dineodecanoate
PATcat 3027	Dimethyltin dilauryl mercaptide
PATcat 3030	Dimethyltin di (2-ethylhexyl thioglycolate)
PATcat 3003	Dibutyltin diacetate
PATcat 3004	Dibutyltin dineodecanoate
PATcat 3001	Dibutyltin dilaurate
PATcat 3020	Dibutyltin dilaurate (lower crystallization temperature)
PATcat 3014	Dibutyltin lauryl mercaptide
PATcat 3026	Dibutyltin di (2-ethylhexyl thioglycolate)
PATcat 3046	Dibutyltin di (2-ethylhexyl thioglycolate)
PATcat 3025	Dibutyltin di (2- ethylhexyl maleate)
PATcat 3006	Dibutyltin acetyl acetonate
PATcat 3018WB	Dibutyltin dilaurate
PATcat 3031	Dibutyltin thioglyceride
PATcat 3023	Dioctyltin diacetate
PATcat 3024	Dioctyltin dineodecanoate
PATcat 3005	Dioctyltin dilaurate
PATcat 3022	Dioctyltin di (2-ethylhexyl thioglycolate)
PATcat 3029	Dioctyltin di (lauryl mercaptide)
PATcat 3016	Dioctyltin acetyl acetonate

TIN-FREE CATALYSTS

Tin-free Catalysts			
Solvent based		**Water based**	
Bismuth		**Bismuth**	
PATcat 4005	All purpose	**PATcat 4012**	Hydrolytically stable
PATcat 4006	Most economical	**PATcat 4013**	Hydrolytically stable
PATcat 4007	2EHA-free	**PATcat 4007**	All purpose
Bi/Zn		**Bi/Zn**	
PATcat 4009	Balanced	**PATcat 4009**	Balanced
Zinc		**Zinc**	
PATcat 9001	Most economical	**PATcat 9001**	Most economical
PATcat 9002	All purpose	**PATcat 9003**	2EHA-free
PATcat 9003	2EHA-free	**PATcat 9009**	Longer pot life
PATcat 9009	Longer pot life		
Aluminum			
PATcat 17002			
Other Delayed action catalysts		**Other Delayed action catalysts**	
PATcat 19060	Better pot life, non toxic	**PATcat 19060**	Better pot life, non toxic

1K Isocyanate blocking agent

PATOX 1

- MEKO Methyl Ethyl Ketoxime

Also referred as Mercury Replacement Catalysts

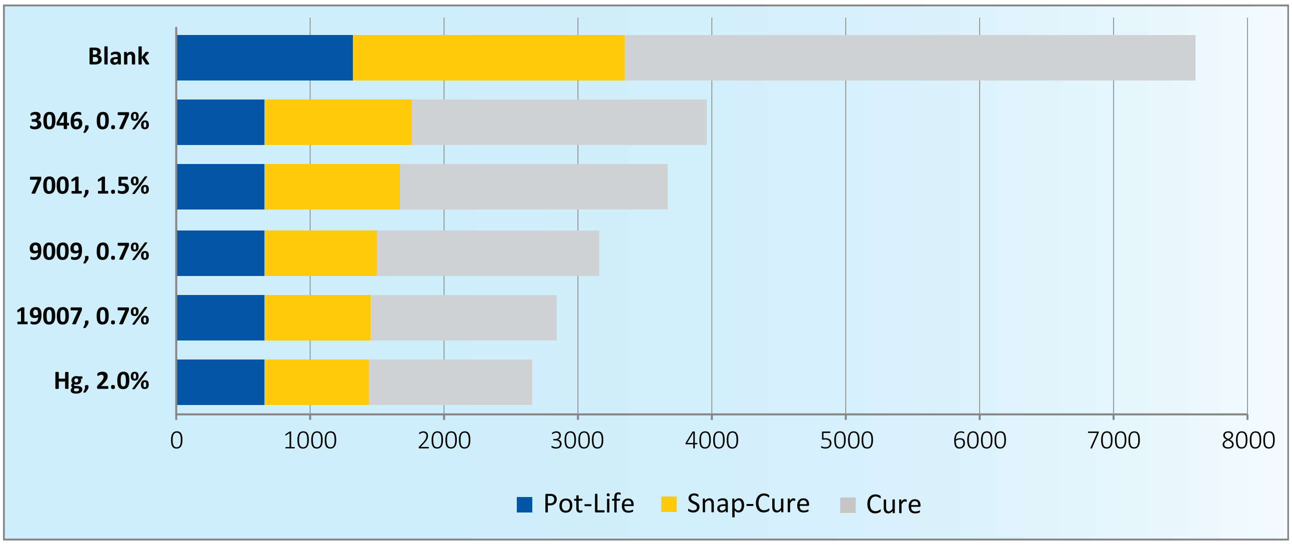
- These catalysts show low initial activity at ambient temperature.
- Their activity increases as the exotherm rises over time and/or when external heat is applied.

Delayed action catalysts

PATcat

PRODUCT	
3022	Tin based
3029	Tin based
3026	Tin based
3046	Tin based
7001	Nickel based
9009	Tin-Free / Nickel-Free
19007	Improved Snap-Cure. Colorless

Comparison of PATcat Catalysts



Time / secs

PATCHAM

PATCHAM INDIA

B-52, Pravasi Industrial Estate, Vishweshwar Nagar,
Off Aarey Road, Goregoan (E)
Mumbai-400 063
Tel.: +91 96191 50550

PATCHAM USA LLC

10 Commerce Road
Fairfield, New Jersey - 07004
Tel.: (201) 293 4282
Fax: (201) 820 0818
Email: officeadmin@patchamusa.com

PATCHAM EUROPE BV

Dorpsstraat 24 A,
7451 BV Holten, Netherlands
Tel.: +31 630723609
Emai: eu@patcham.com

PATCHAM (FZC)

P. O. Box : 7753, SAIF Zone, Sharjah, UAE
Tel.: +971 65570035
Fax: +971 65570038
Email: patcham@eim.ae

www.patchamltd.com

Ver. 2.3