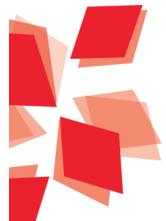


Cross-linking of CREAMID

<Kunde>

<Datum>

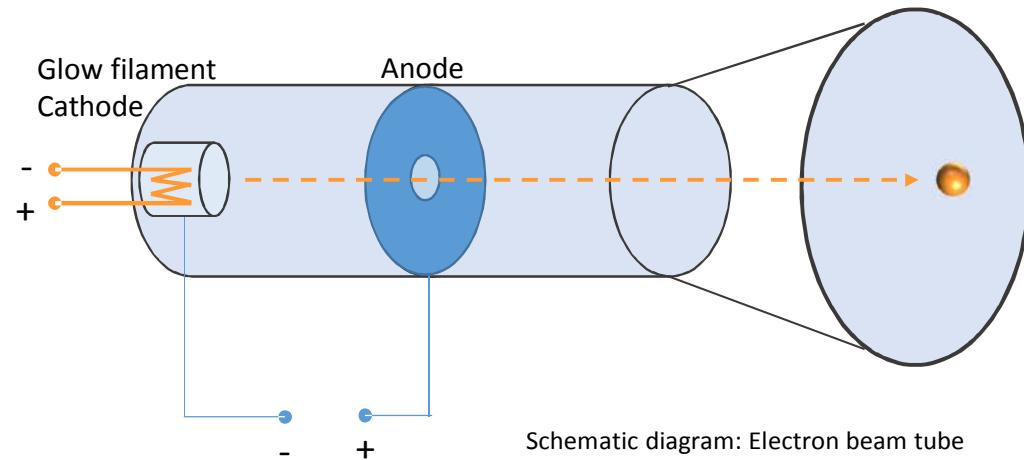
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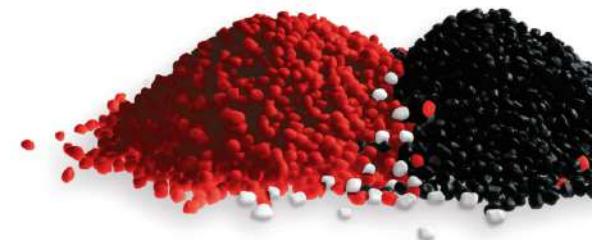
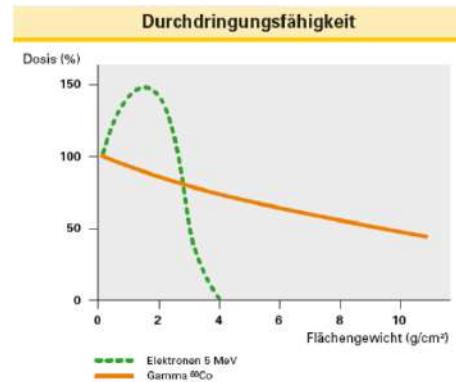
Cross-linking?

could not be less confidential

- Particle radiation, „**e-beams**“:
Accelerated electrons,
„simple“ electrical device



E-beam accelerator

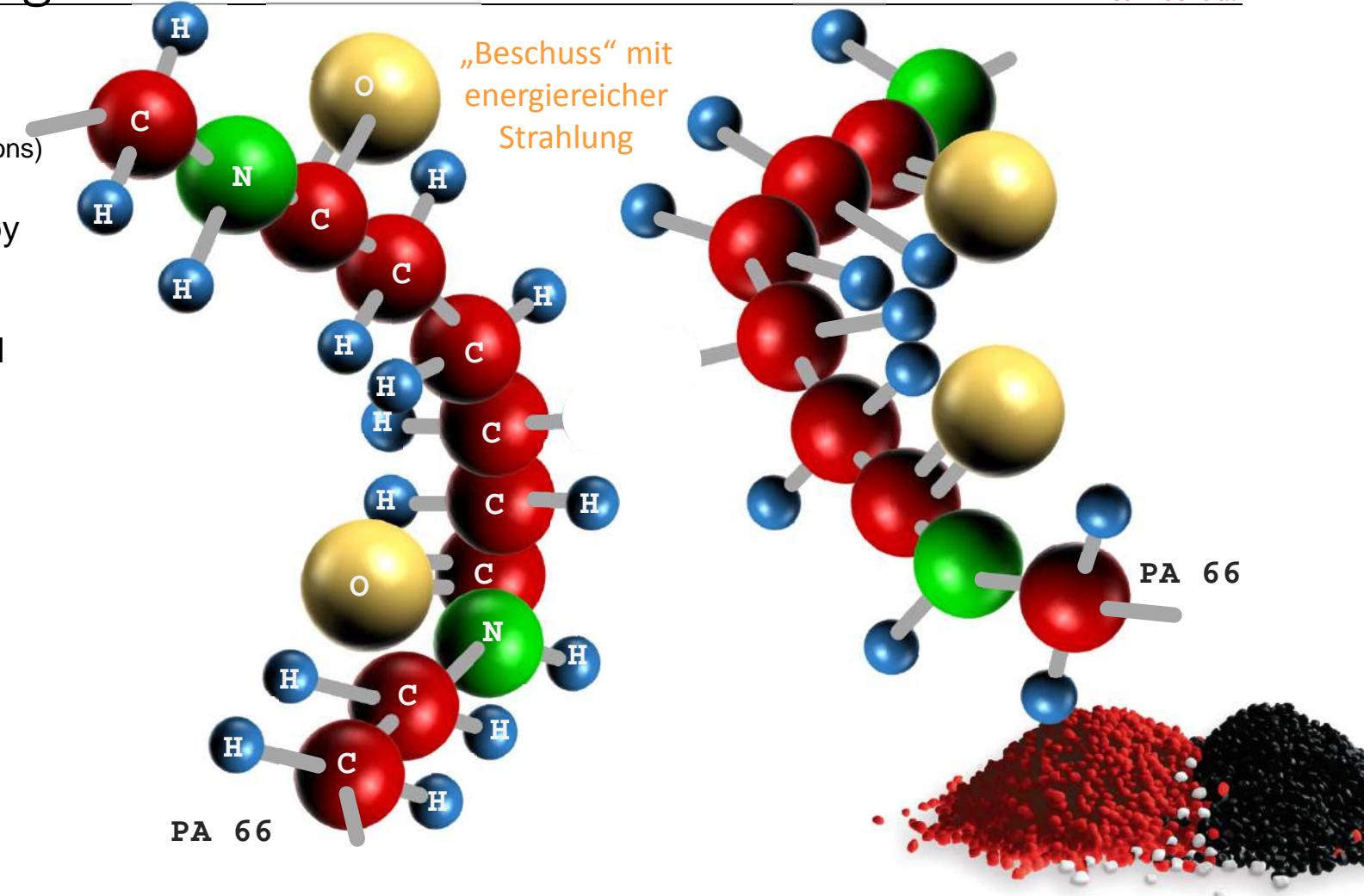




- **Radiation** is energy
(kinetic energy of accelerated electrons)
- Energy is being absorbed by
the so treated material
- Chemical reaction is initiated
(creation of radicals)

Cross-linking?

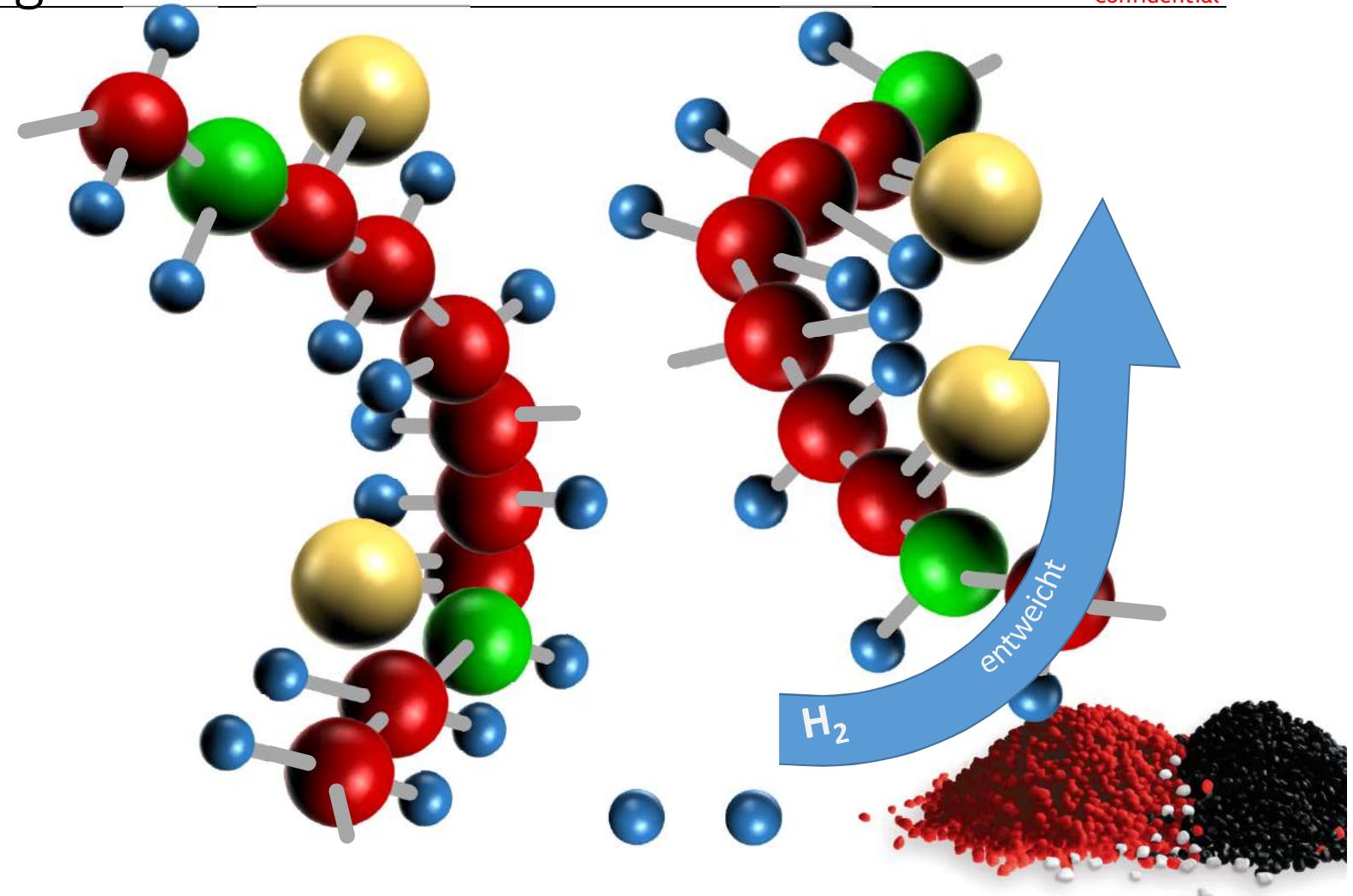
could not be less
confidential

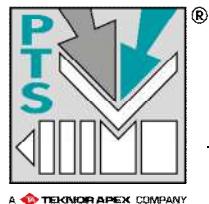




Cross-linking?

could not be less
confidential



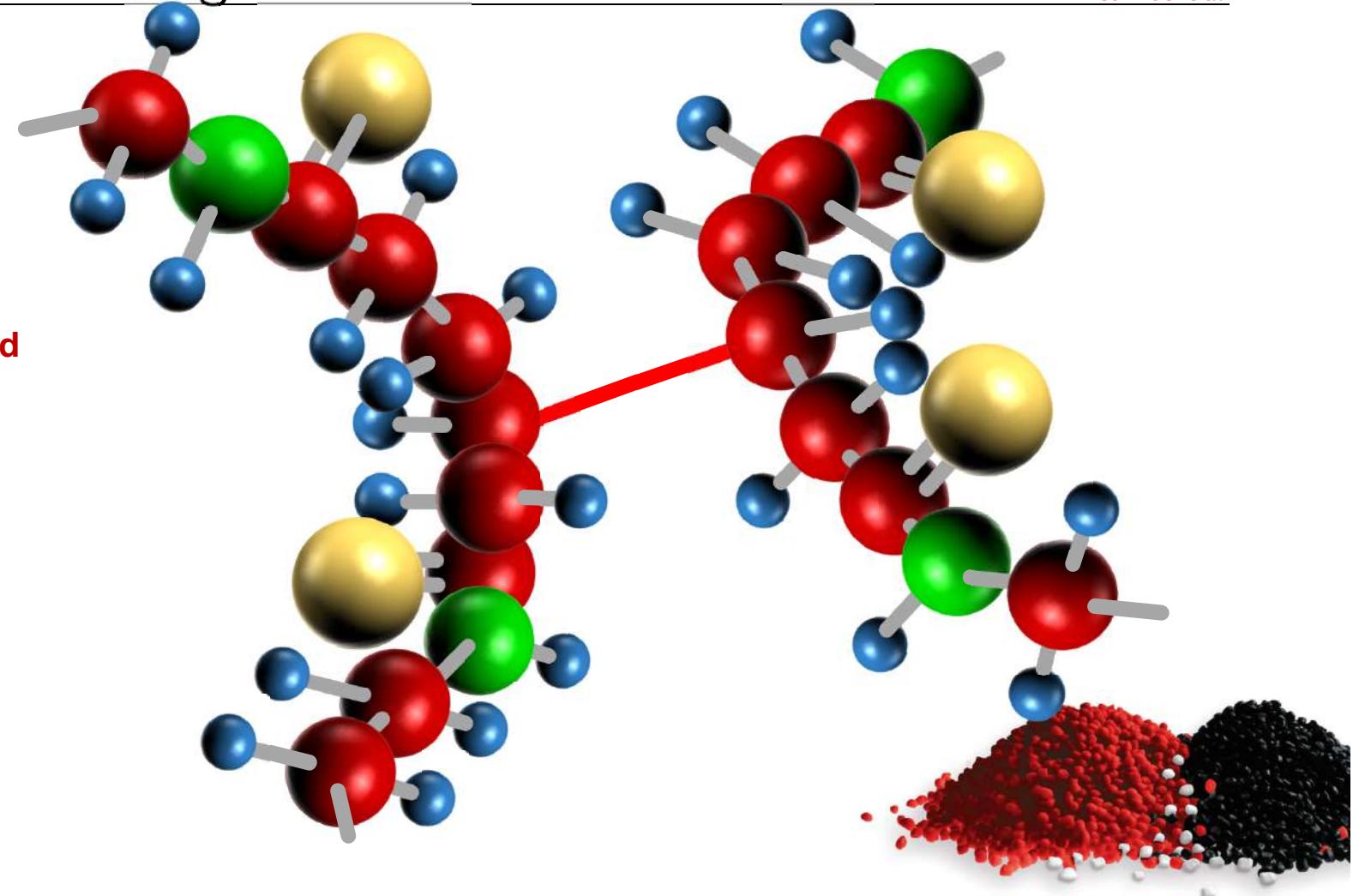


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Strahlenvernetzung?

could not be less
confidential

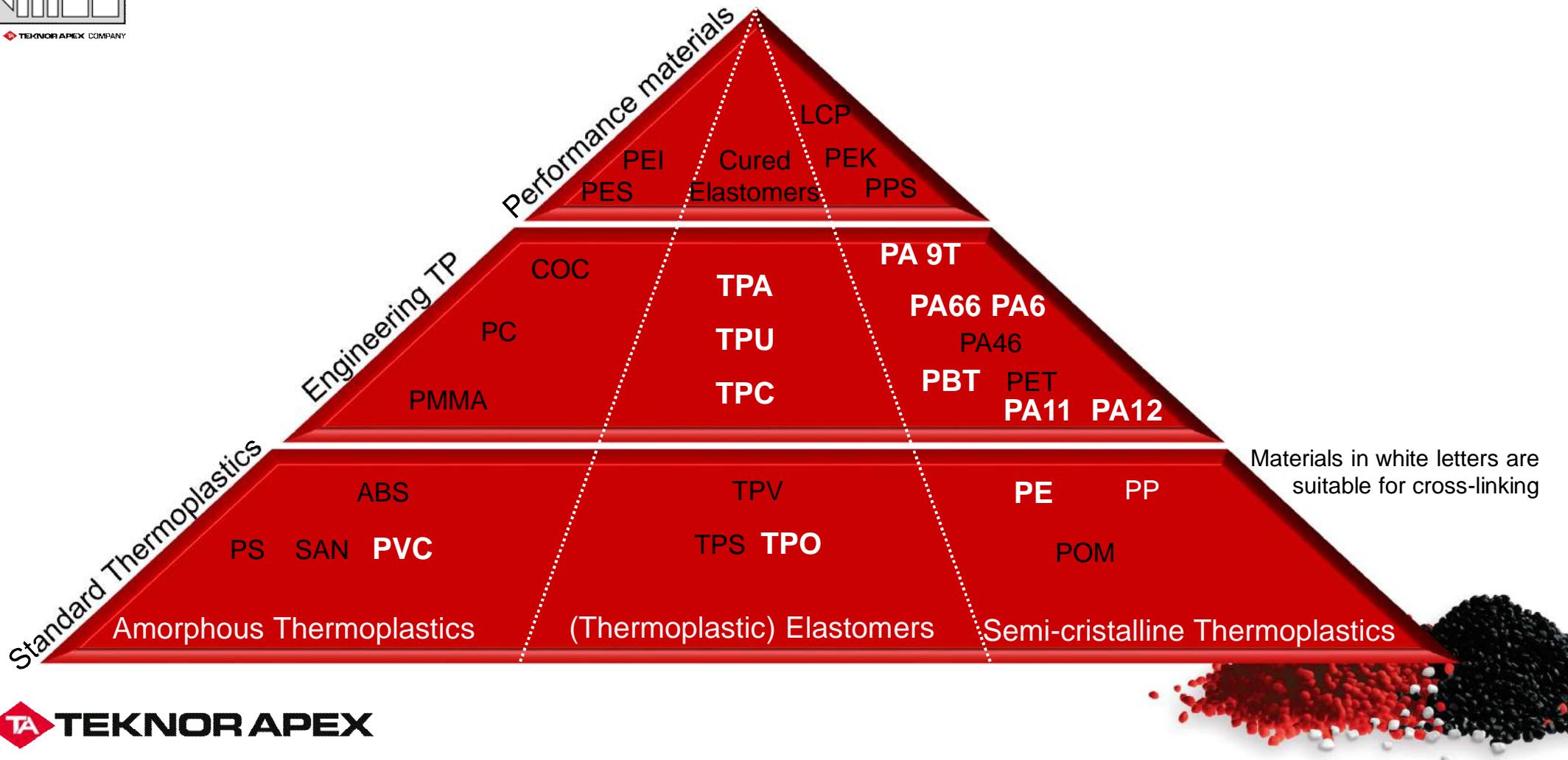
- Supported by BETALINK®
(not visualized here!)
free radicals will recombine
⇒ **Polyamide is cross-linked**





Cross-linking: Suitable materials

could not be less
confidential





Cross-linkable Polymers

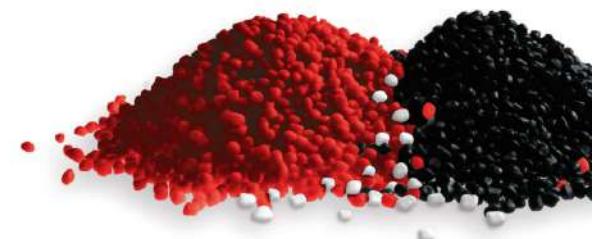
could not be less
confidential

- Irradiated polymers are NOT radioactive!



- Important:

*Untreated and treated parts must not be mixed up!
(It is impossible to distinguish between cross-linked and not yet irradiated parts)*

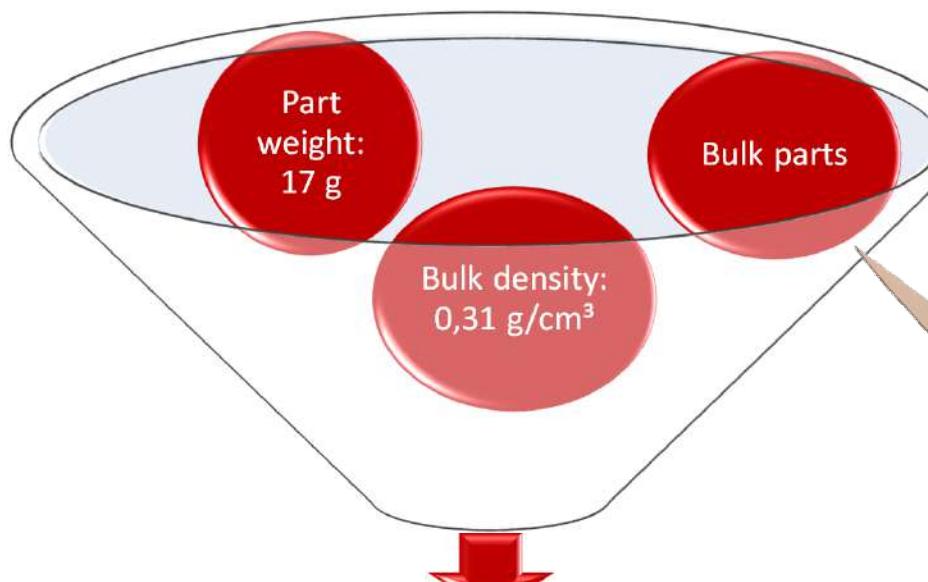




Cross-linkable Polymers

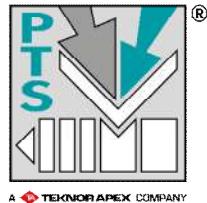
could not be less
confidential

- E-beam treatment of plastic parts is expensive!



Surcharge: 0,02 €/part



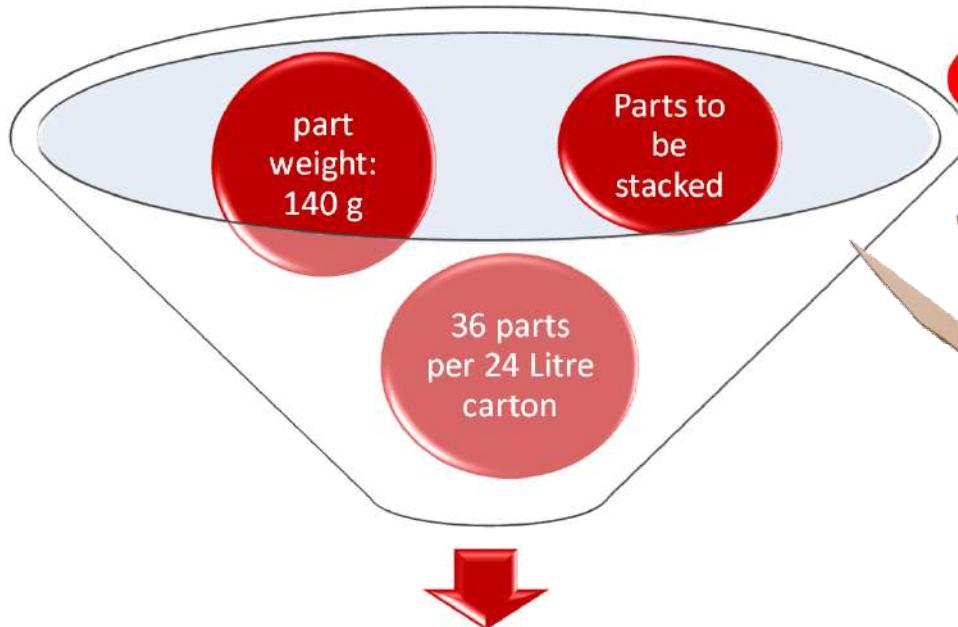


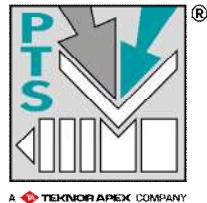
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Cross-linkable Polymers

could not be less
confidential

- E-beam treatment of plastic parts is expensive!

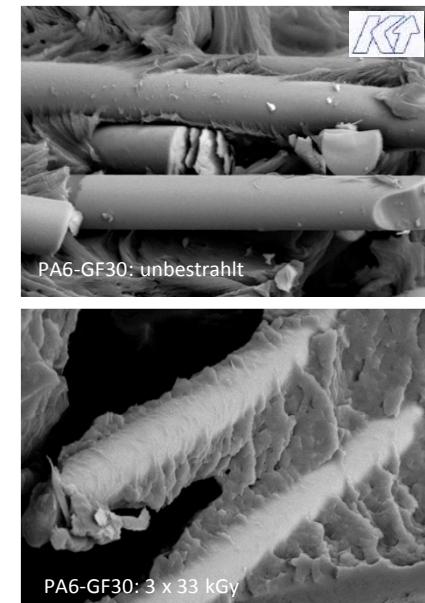
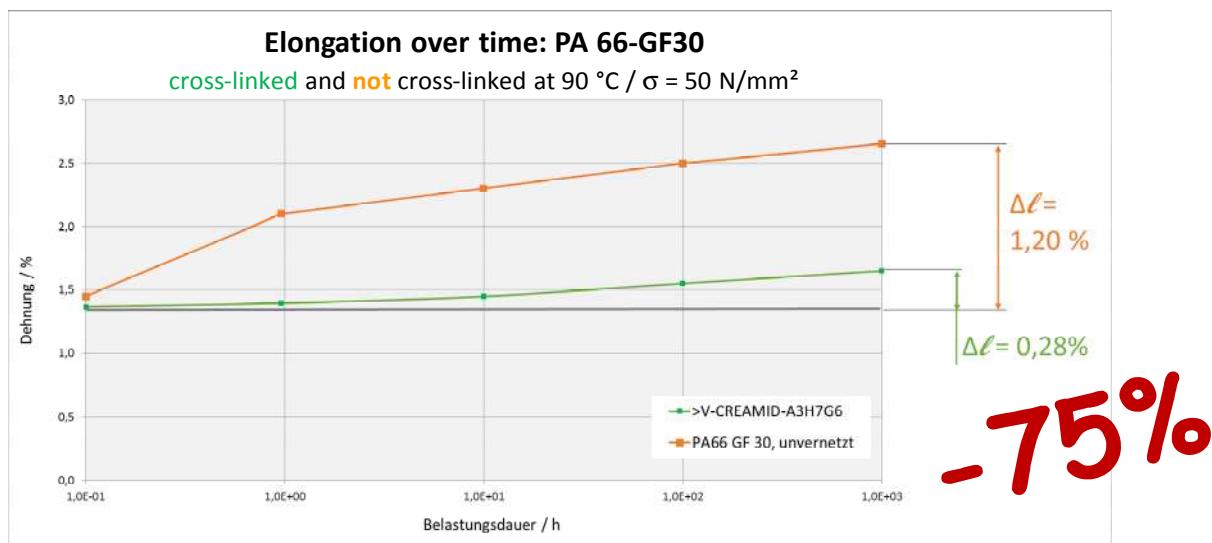




Cross linking of polymers: Why?

could not be less
confidential

Improving		thermal	properties of thermoplastics
mechanical	chemical	tribological	



SEM Pictures: University of Erlangen-Nuernberg



Cross-linking of polymers: Why?

could not be less
confidential

Improving	mechanical	
	thermal	properties of thermoplastics
	chemical	
	tribological	



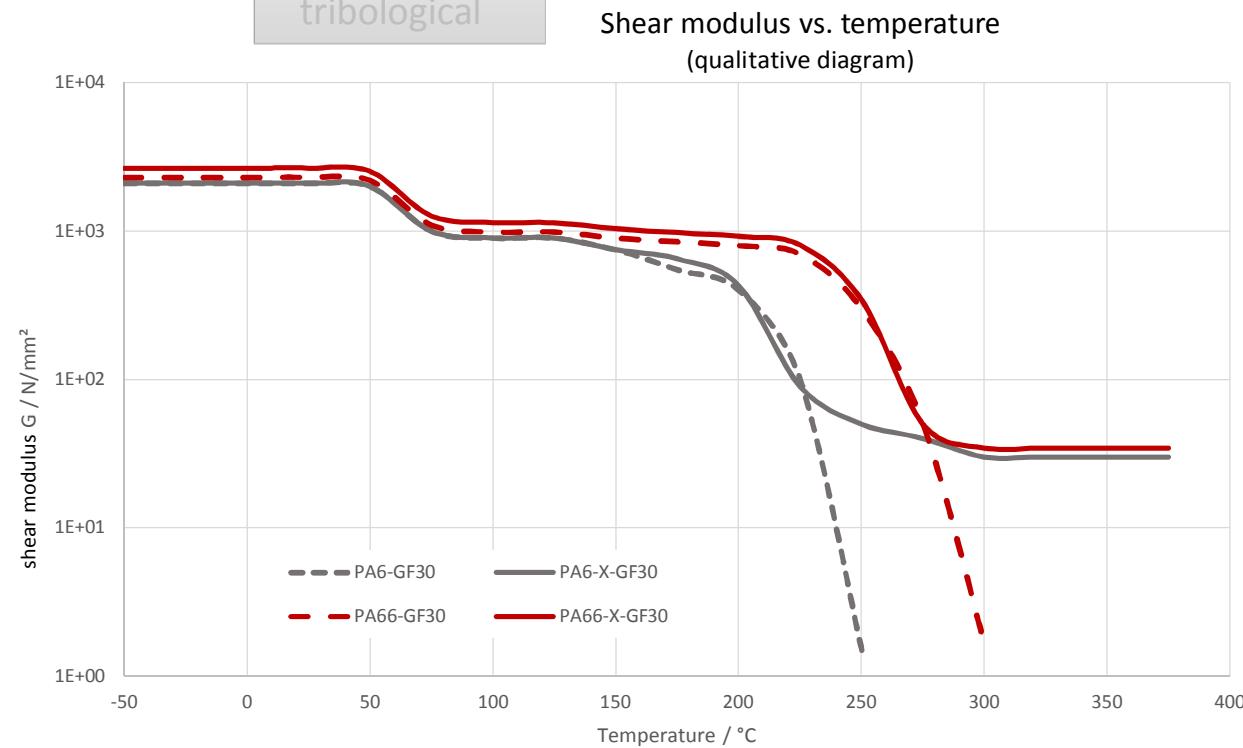


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Cross-linking of polymers: Why?

could not be less
confidential

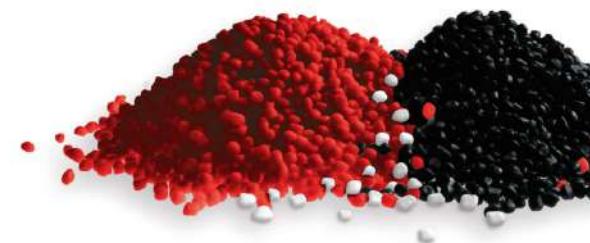
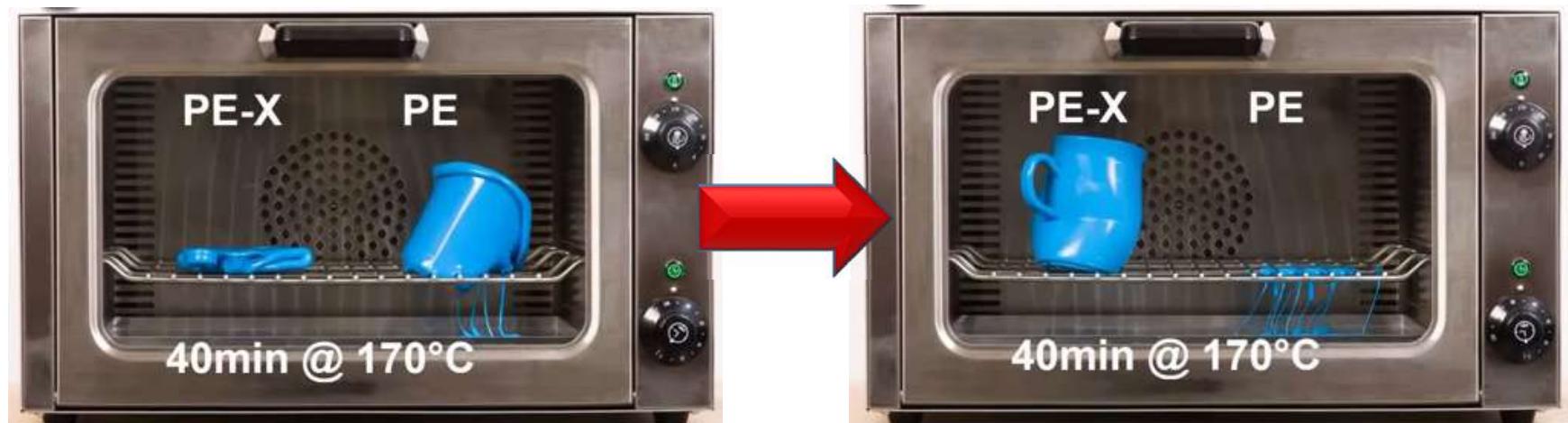
mechanical		
improving	thermal	properties of thermoplastics
	chemical	
	tribological	





Cross-linking of polymers: Why?

could not be less
confidential



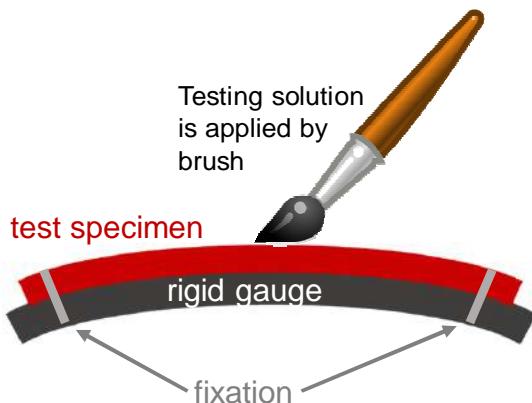


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Cross-linking of polymers: Why?

could not be less
confidential

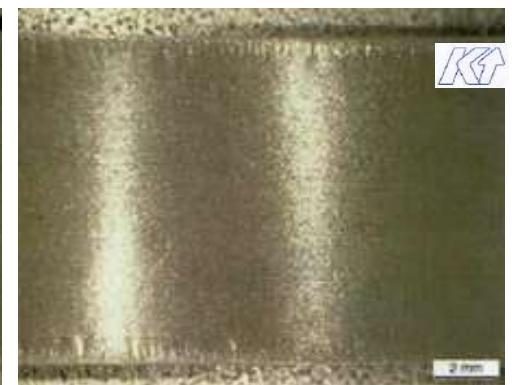
		thermal	
Improving	chemical	properties of thermoplastics	
	tribological mechanical		



not irradiated



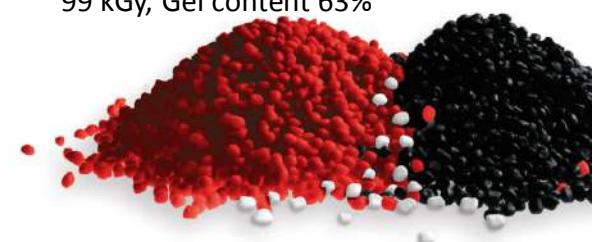
33 kGy, Gel content 60%



99 kGy, Gel content 63%

Flexural strain test
University of Erlangen-Nürnberg

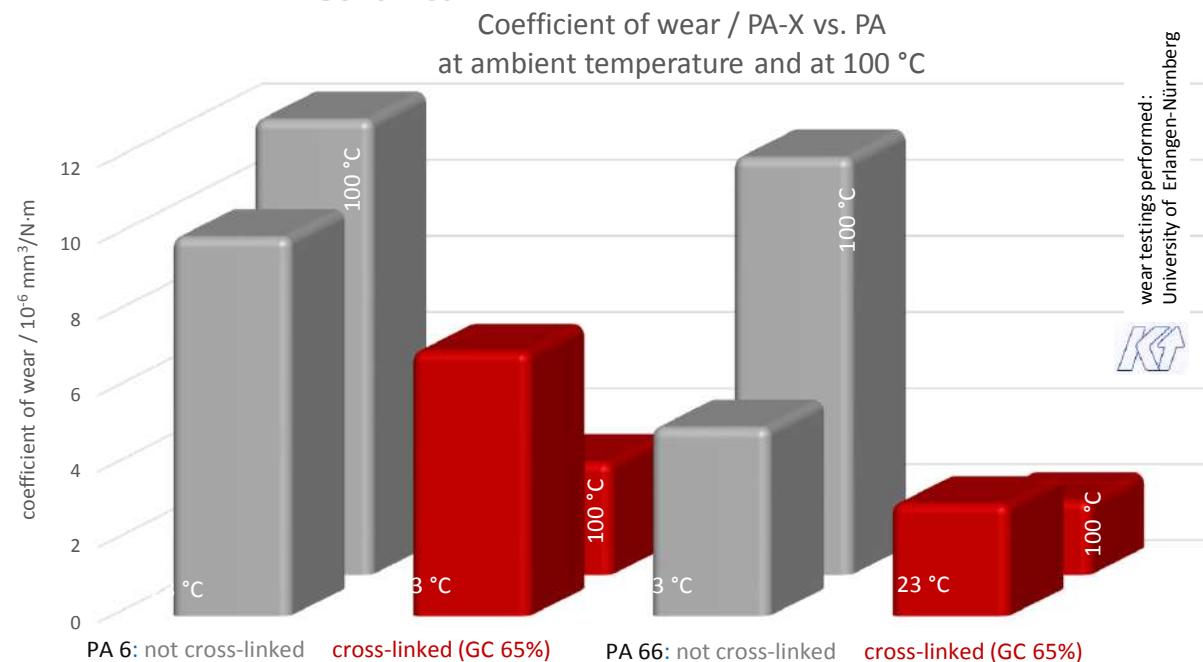
TEKNOR APEX



Cross-linking of polymers: Why?

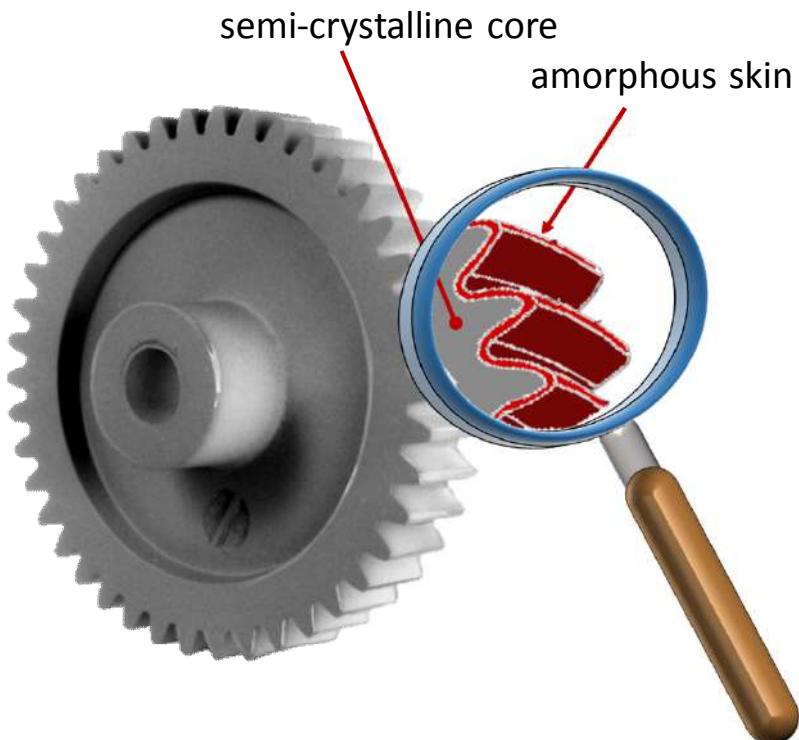
could not be less confidential

Improving	thermal	properties of thermoplastics
	tribological	
	chemical	
	mechanical	



Improving wear and tear behaviour

*could not be less
confidential*



Polyamide is a semi-crystalline material.
Cristallinity is about (40±5) %
[Ehrenstein: *Polymer-Werkstoffe*, Hanser-Verlag]

Crystallinity of injection moulded parts is not distributed homogenously over the cross-section of those parts. By cooling down the melt at the temperature controlled cavity wall, areas with amorphous molecular structures are created. Thickness of these areas („skin“) is depending on cooling velocity ($\frac{\text{°C}}{\text{min}}$)

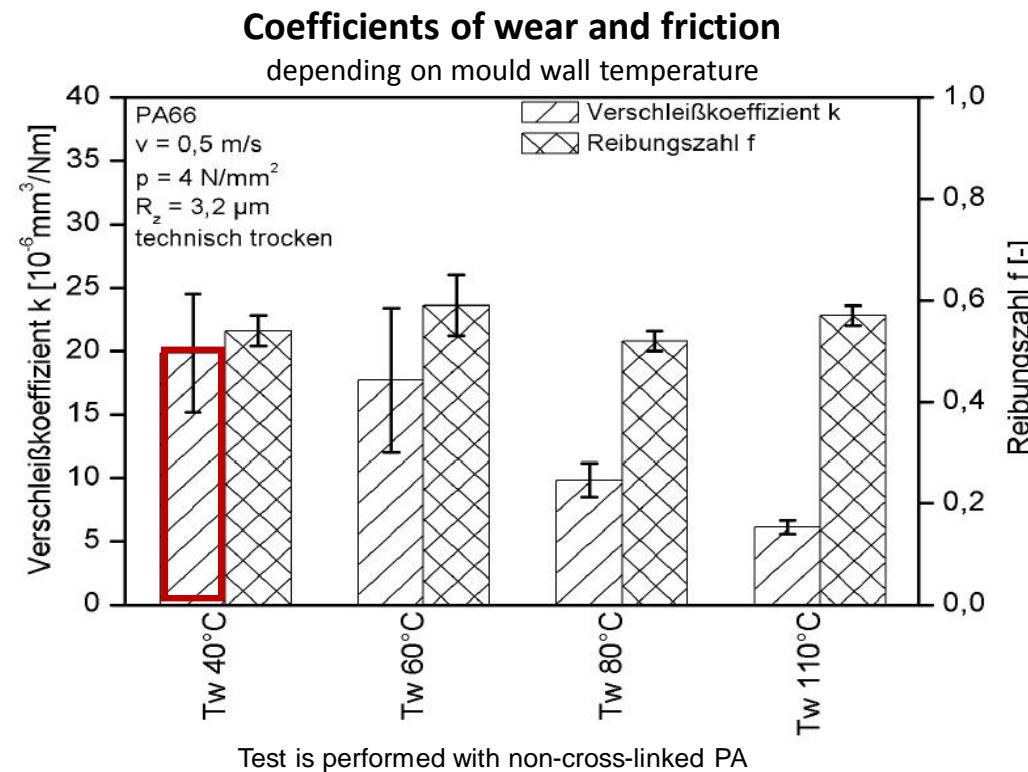
These amorphous areas – with thermally and mechanically weaker properties compared to semi-crystalline areas- are contact surfaces to the environment and determin the part's performance.



Variation of crystallinity

could not be less confidential

by variation of mould wall temperature



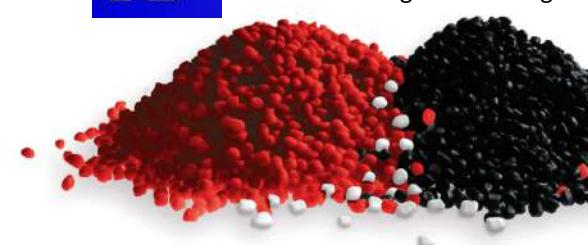
Low mould wall temperature is causing high cooling velocity of skin area resulting in **low crystallinity**.

Low skin crystallinity (\rightarrow amorphous) is causing **high coefficient of wear (k)**

Source:



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 Universität Erlangen-Nürnberg



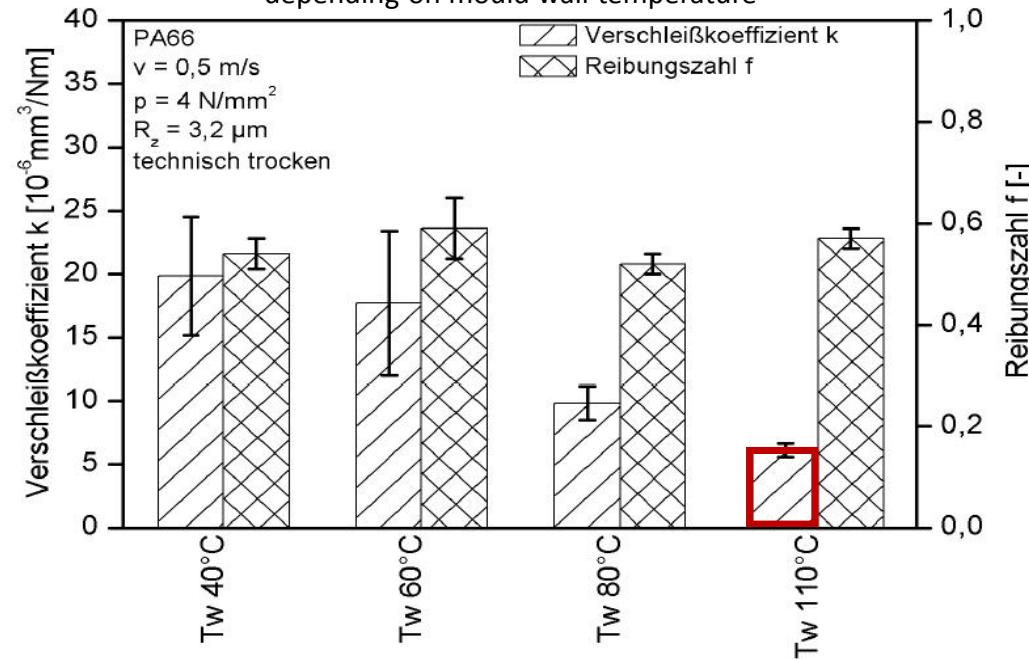
Variation of crystallinity

by variation of mould wall temperature

could not be less confidential

Coefficients of wear and friction

depending on mould wall temperature



Vice versa:

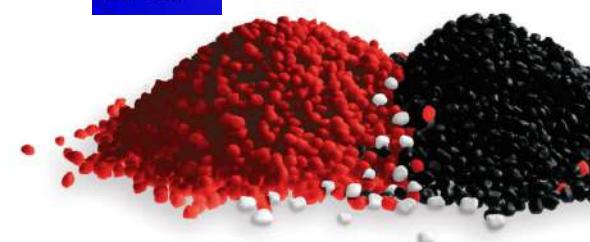
High mould wall temperature is causing low cooling velocity of skin area resulting in **high crystallinity**.

High skin crystallinity is resulting in **low coefficient of wear (k)**

Source:

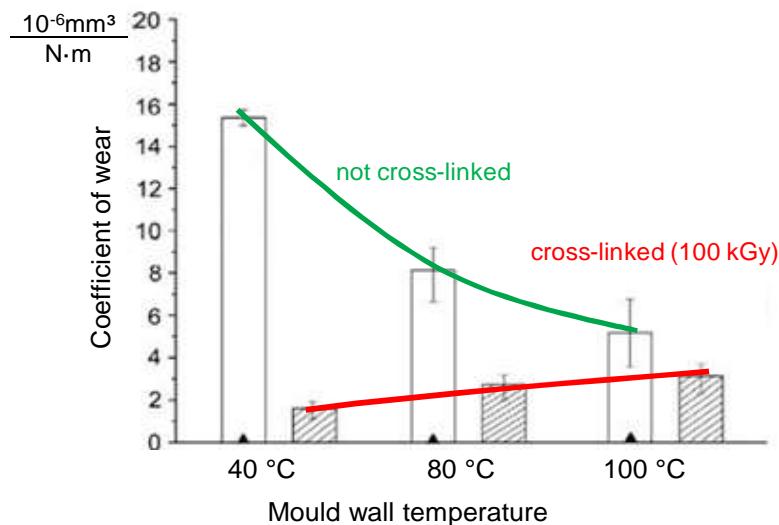


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Universität Erlangen-Nürnberg



Variation of crystallinity

*could not be less
confidential*



Test setup



Pin-on-disk test
wear combination:

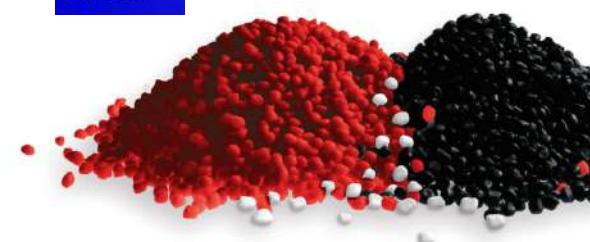
- PA 66, cross-linked (3 x 33 kGy) and not cross-linked PA66
- Steel, $R_z = 1,5 \mu\text{m}$

$T_U = 100^\circ\text{C}$, $v = 0,5 \text{ m/s}$, $p = 4 \text{ N/mm}^2$

Source:



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University of Erlangen-Nürnberg

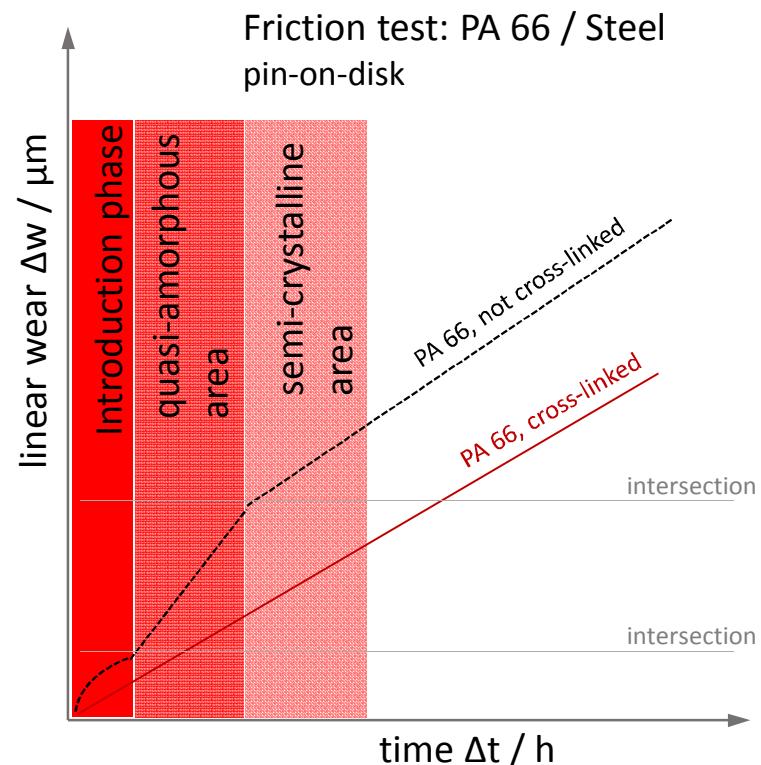


Wear behaviour of different areas

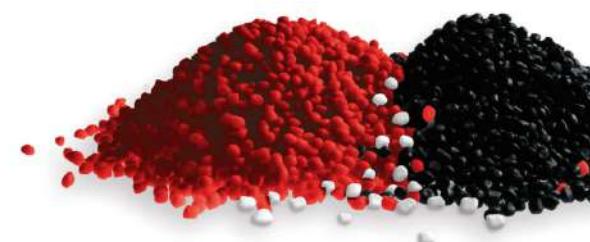
could not be less confidential

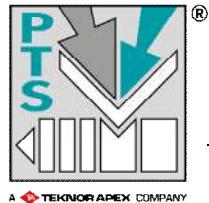
Qualitative diagram of wear depending on polymer morphology

Source: LKT, Uni Erlangen-Nürnberg



By e-beam treatment, mainly amorphous skin areas are cross linked. Resistance against wear is shifted directly into semi-crystalline areas





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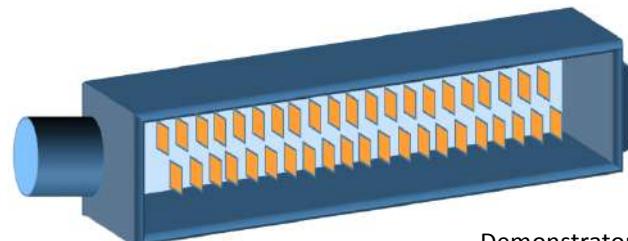
Cross-linking of polymers: Why?

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confidential

thermal		
Improving	costs	of thermoplastic parts
	chemical tribological	

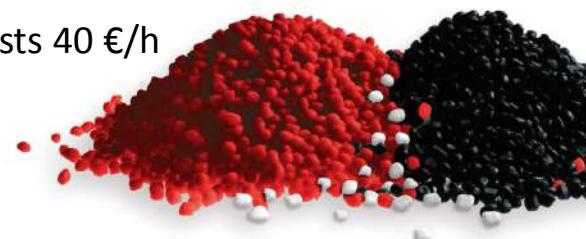
Example: Multi-Connector, L x B x T = 80 mm x 20 mm x 20 mm

Requirements: CTI > 400, lead-free reflow soldering process



Injection moulding

Boundary condition: 4 cavity tool, machine operating costs 40 €/h





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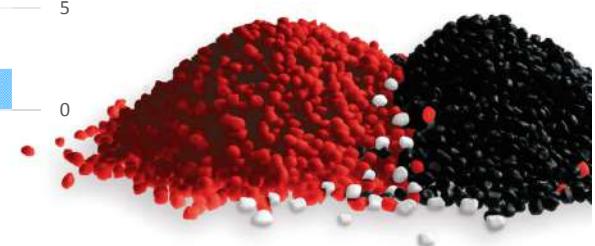
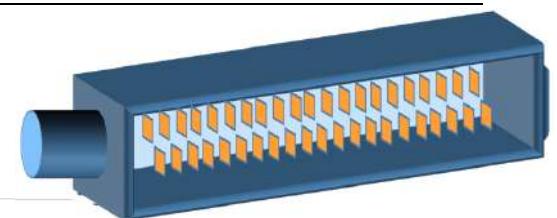
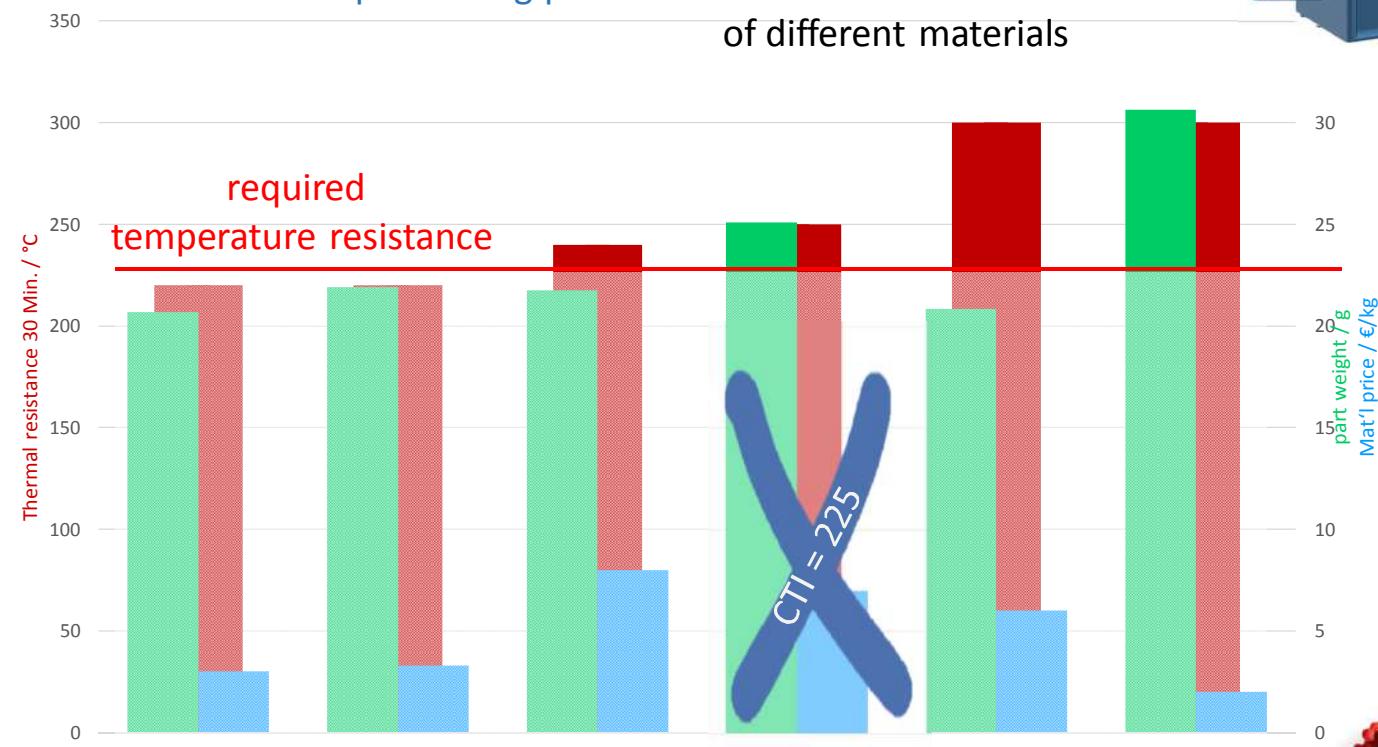
Cross-linking of polymers: Why?

could not be less confidential

Graphical diagram of

- short-time temperature resistance
- part weight
- purchasing price

of different materials



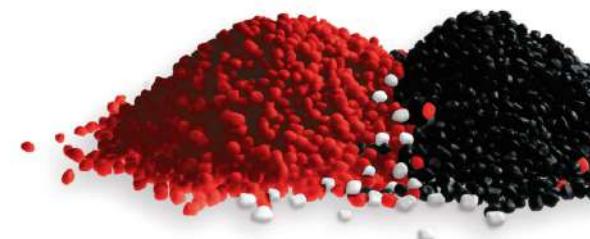
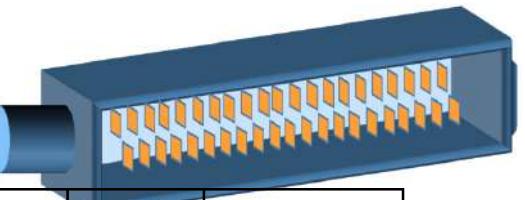
Cross-linking of polymers: Why?

could not be less confidential

Example: Wall thickness d = 1,0 mm is given

Material	Part weight	Material price	Mat'l deployment	Cycle time without remaining cooling time	Remaining curing time rsp. curing time	Cycle time	Manufacturing time 1.000 parts / h	Machine costs/1.000 parts at expected cycle time / €	Subsequent machining/ 1.000 pt	Manufacturing costs: Material + Machine + Sub'mach
	g	€/kg	€/1.000 parts		s	s		40	€	€/1.000 parts
PA66-GF30	10,9	3,00	32,693	17	3	20	1,389	55,56	0	88,248
PA66-GF30 FR(30)	11,5	3,30	38,077	17	3	20	1,389	55,56	0	93,633
PPA-GF30 FR(40)	11,5	8,00	91,667	17	3	20	1,389	55,56	0	147,223
PPS-GF40	13,2	7,00	92,549	17	3	20	1,389	55,56	0	148,104
PA66-X-GF30	11	6,00	65,866	17	3	20	1,389	55,56	18	129,421
UP-GF20 FR	18	2,00	36,045	17	40	57	3,958	158,33	20	204,378

Not taken into account: different energy consumption → costs (melt temp., machine pressure,...)



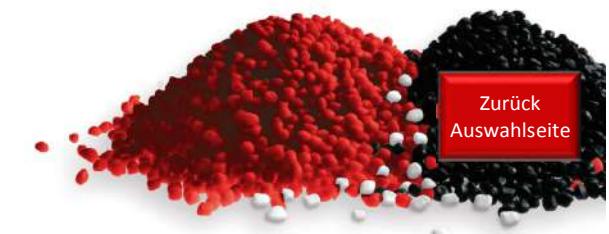
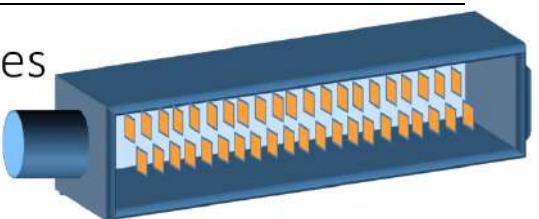
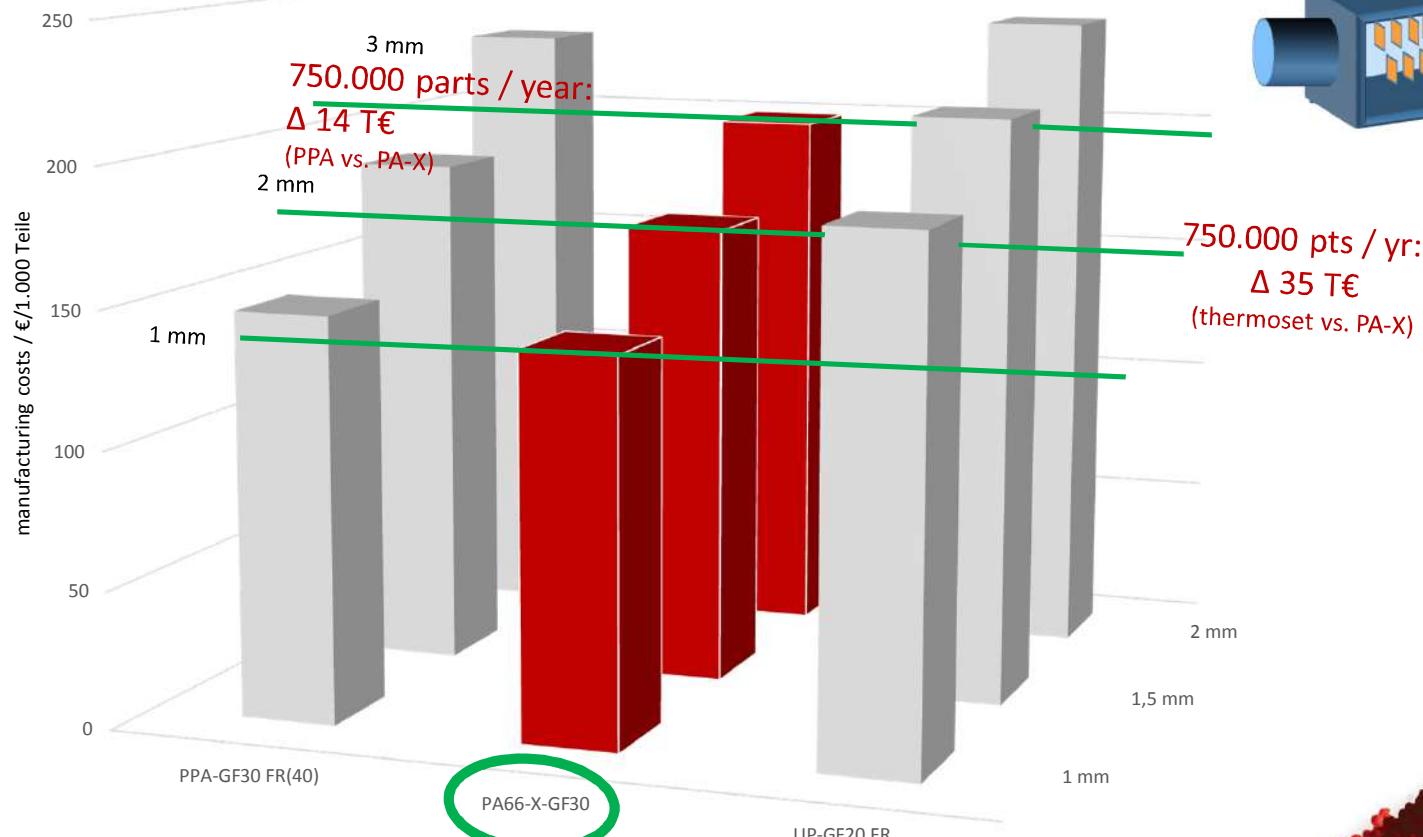


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Cross-linking of polymers: Why?

could not be less confidential

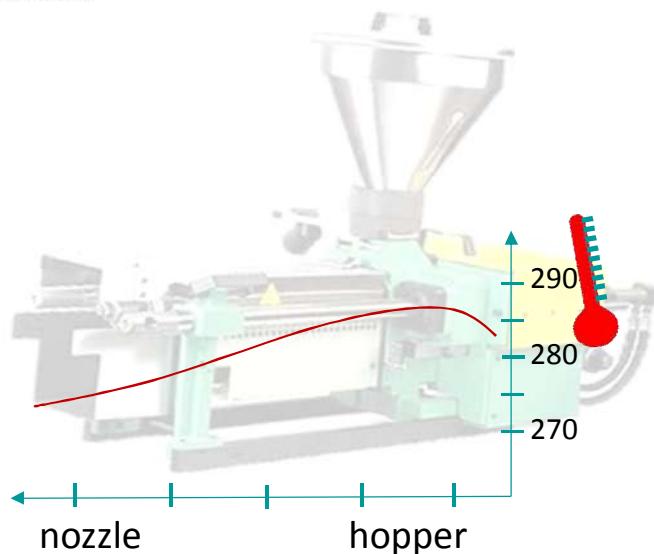
Manufacturing costs at different wall thicknesses



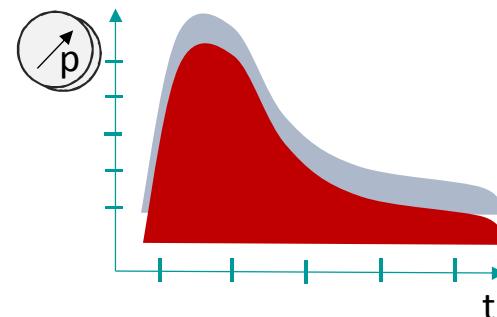
Zurück
Auswahlseite

Cross-linking of polymers: How?

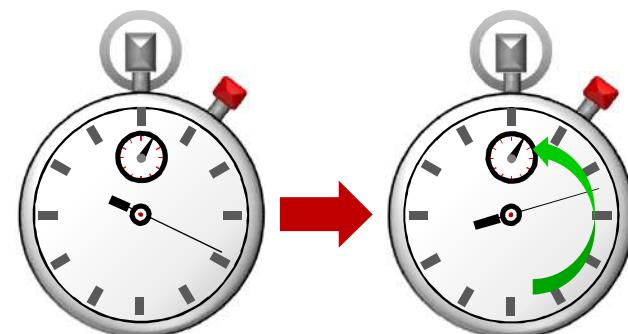
*could not be less
confidential*



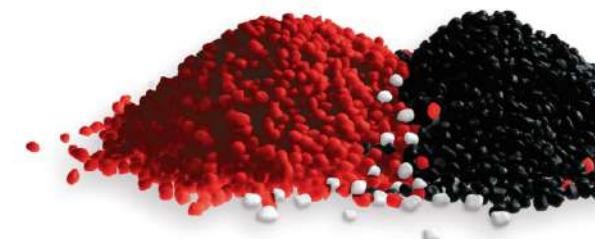
Parameter variation in moulding process

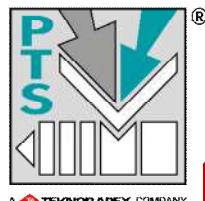


e.g.: (PA66+PA6I/6T)-GF40
flow length approx. 530 mm



with cross-linking agent: approx. 600 mm





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Cross-linking of polymers: How?

could not be less confidential

Chemische Bezeichnung: 1,3,5-Triallyl-1,3,5-triazin-2,4,6(1H,3H,5H)-trion
CAS-Nr.: 1025-15-6
REACH-Regis-Nr.: 01-2119932313-47-0000
EG-Nr.: 213-834-7

1.2. Relevante identifizierte Verwendungen des Stoffs oder Gemisches und Verwendungen, von denen abgeraten wird

Relevante identifizierte Verwendungen: Gummi und Kunststoff Ind Die ausführlichen Expositi Funktion: Vernetzer

1.3. Einzelheiten zum Lieferanten, der das Sicherheitsdokument erstellt hat

Firma: Evonik Performance Materie Postfach 1345 D-63403 Hanau

Telefon: +49 (0)6181 59-3207
Telefax: +49 (0)6181 59-2083
Email Adresse: sds-info-epm@evonik.com

1.4. Notrufnummer

Notfallauskunft: +49 (0)2365 49-2232 (Dolmetscherservice verfügbar)
Notfallauskunft: +49 (0)2365 49-4423 (Telefax)

ABSCHNITT 2: Mögliche Gefahren

2.1. Einstufung des Stoffs oder Gemisches

Einstufung gemäß Verordnung (EG) Nr. 1272/2008 [CLP].

EU-CLP gemäß Verordnung (EG) Nr. 1272/2008

Akute Toxizität (Oral)	Kategorie 4	H302
Akute Toxizität (Haut)	Kategorie 4	H312
Spezifische Zielorgan-Toxizität (wiederholte Exposition) (Oral, Haut, Leber)	Kategorie 2	H373

2.2. Kennzeichnungselemente

Kennzeichnung gemäß (EG) 1272/2008

Gesetzliche Grundlage: EU-CLP gemäß Verordnung (EG) Nr. 1272/2008

Gefahrenbestimmende Komponente(n) (GHS)

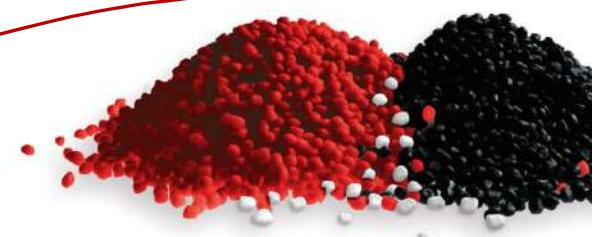
- 1,3,5-Triallyl-1,3,5-triazin-2,4,6(1H,3H,5H)-trion

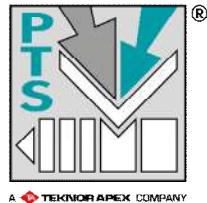
Symbol(e):



**Deployment of the product:
Processing agent in rubber- and plastic processing industry**

Toxizität bei wiederholter Aufnahme	Methode: OECD TG 406 Oral Ratte(männlich) / 4 Wochen NOAEL: 15 mg/kg Zielorgan/Wirkung: Leber Methode: OECD TG 407 Literatur
Beurteilung STOT-Einmalige Exposition	Oral Ratte(weiblich) / 4 Wochen NOAEL: >= 50 mg/kg Zielorgan/Wirkung: Leber Methode: OECD TG 407 Literatur
Beurteilung STOT-Wiederholte Exposition	Expositionsweise: oral Zielorgane: Leber Beurteilung: Der Stoff oder das Gemisch ist als zielorgantoxisch, wiederholte Exposition, der Kategorie 2 eingestuft.
Gefahr der Aspirationstoxizität	Keine Daten vorhanden
Genotoxicität in vitro	Genmutation V 79 - Zelle negativ





Cross-linking of polymers: How?

*could not be less
confidential*

When processing compounds containing Betalink, air /TAIC mixtures can occur.

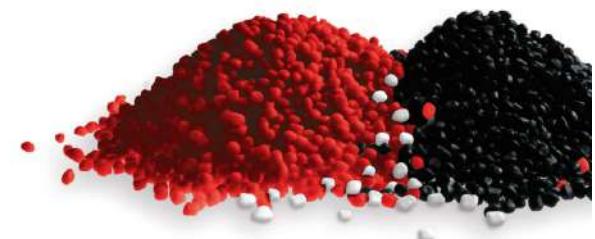
Exposition to be monitored:

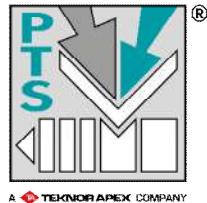
Following parameters shall be monitored while processing TAIC:

(**DNEL** (Derived no-effect-level) / **DMEL** (Derived Minimum Exposure Level)):

Application Exposition possible damages to health value	Employee respiration long term - systemic effects 0,35 mg/m ³
--	--

Exposition possible damages to health value	Dermal long term - systemic effects 0,1 mg/kg body weight/day
---	--





Cross-linking of polymers: How?

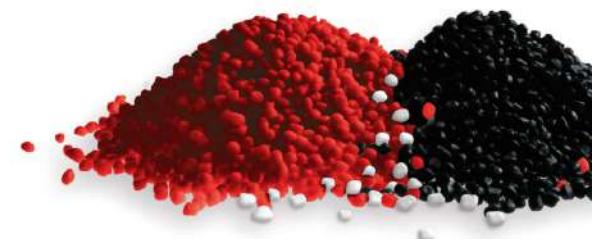
could not be less
confidential

- ! sufficient vapour extraction system
- ! filter cartridges of the extraction system are to be treated as special waste
- ! providing sufficient amount of fresh air
- ! extracted air must not recirculate!

(Exhaust system with sufficient distance to doors, windows and so on)

- ! ***For additional advices see Safety data sheet***
- ! ***Personal protective equipment shall be worn***

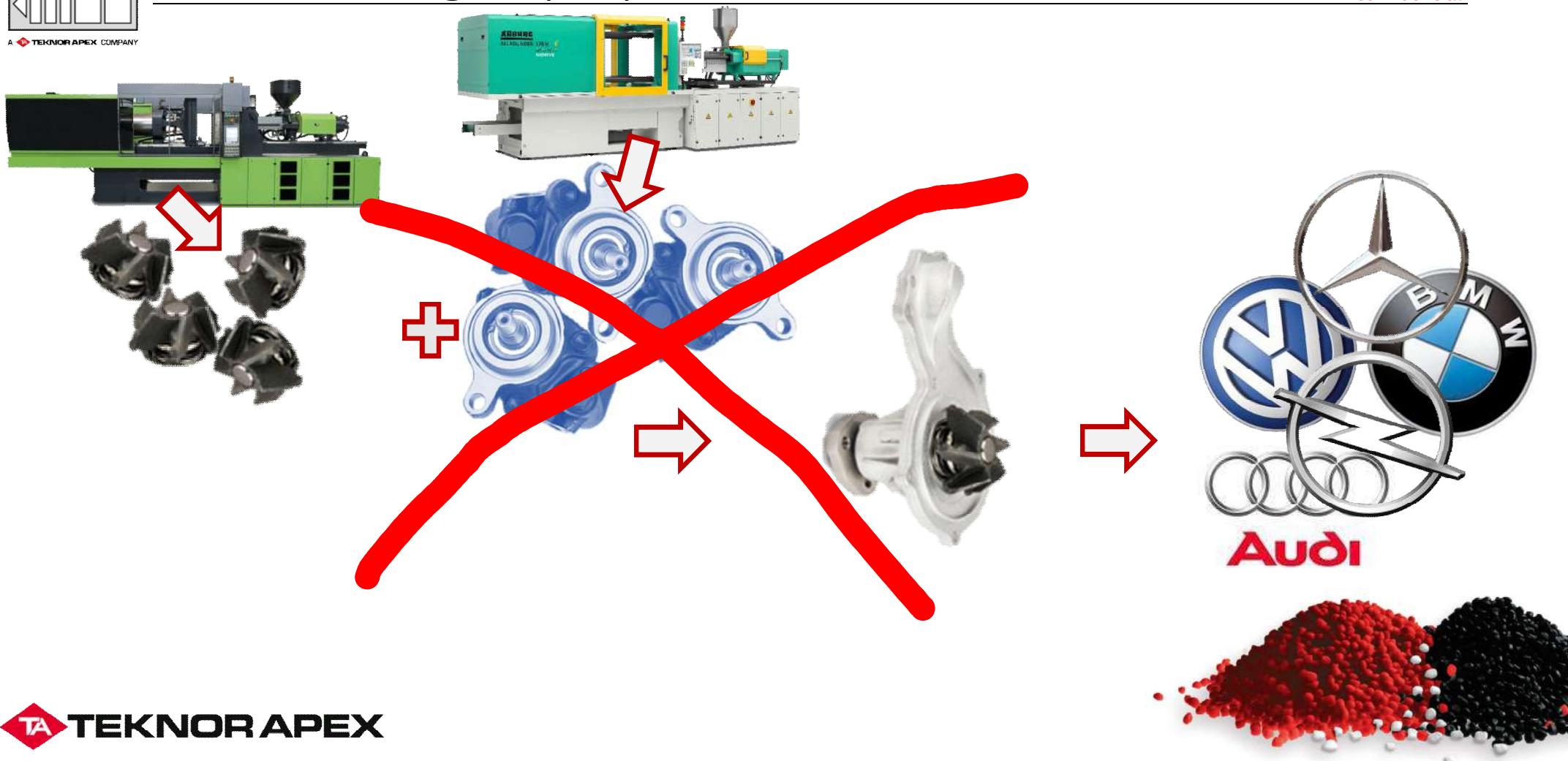
standard industrial hygiene- and safety rules





Cross-linking of polymers: How?

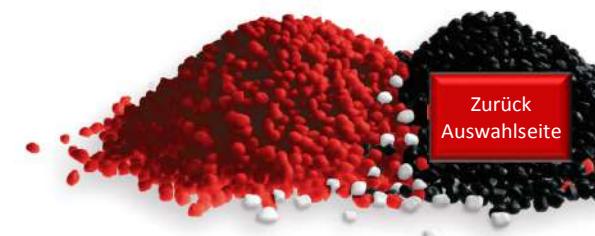
could not be less
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Cross-linking of polymers: How?

could not be less
confidential





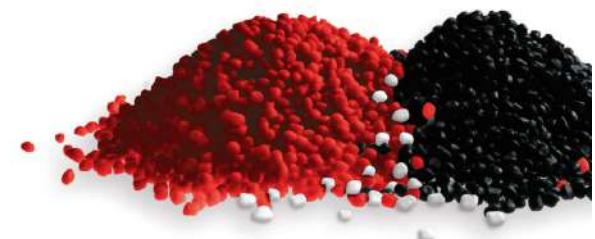
Cross-linking of polymers: How?

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Indicator label on transport container:

- not irradiated
 - 1st treatment >33 kGy
 - 2nd treatment >33 kGy
 - 3rd treatment >33 kGy
- $\Sigma = 100 \text{ kGy}$ ✓





A TA TEKNOR APEX COMPANY

Cross-linking of polymers: Who?

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PORSCHE

SIEMENS

ABB



ITW



EATON
Powering Business Worldwide

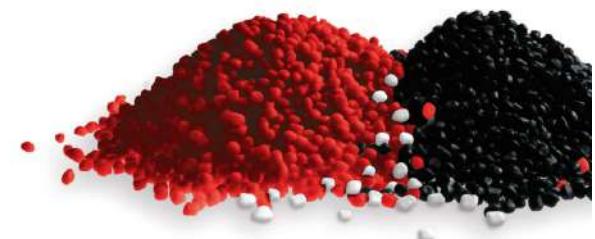
Schneider
Electric

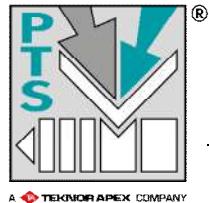
Rockwell
Automation




Audi

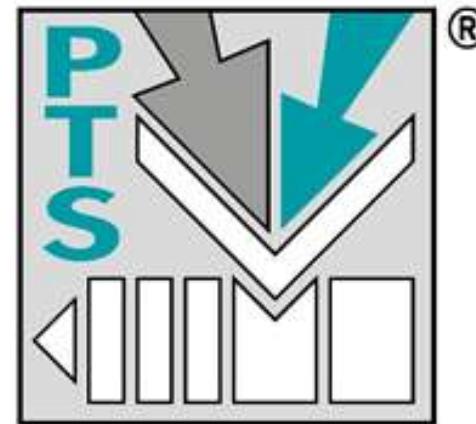






Cross-linking of polymers: Who?

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Teknor Germany GmbH

Thank you for your interest!

