Hybrid adhesion

A novel technology is provided to cope with adhesion of plastics. By Luc Peeters, Kaneka Belgium N.V.

In transportation, construction & building markets the use of lightweight plastic materials keeps growing as these materials will improve the energy efficiency. For instance fuel consumption in cars is cut and buildings can be more efficiently insulated. Besides practical uses, plastics also allow nicer designs, as shaping of plastics in complex forms is easier. (1,2) This trend results in hybrid assemblies, as different types of plastics, metals, wood, … will have to be joined together (3) and require structural "hybrid" adhesives which can adhere materials with different expansion rates and exhibit high adhesive strength to replace welding, riveting and nailing.

Silane Terminated Polyethers

Silane terminated polyethers (STPEs) are one of those materials which already exist for longer time and are known base materials for the development of solvent- and isocyanate-free adhesives which provide primer-free adhesion to a wide range of materials as metals and wood. Recently, a new range of high strength silane terminated polyethers were developed by Kaneka which combine high strength with relative high elongation. [4] In figure 1 the comparison of the strength/elongation ratio between polyurethanes, silicones and the different Kaneka MS Polymer™ technologies is given. [5]

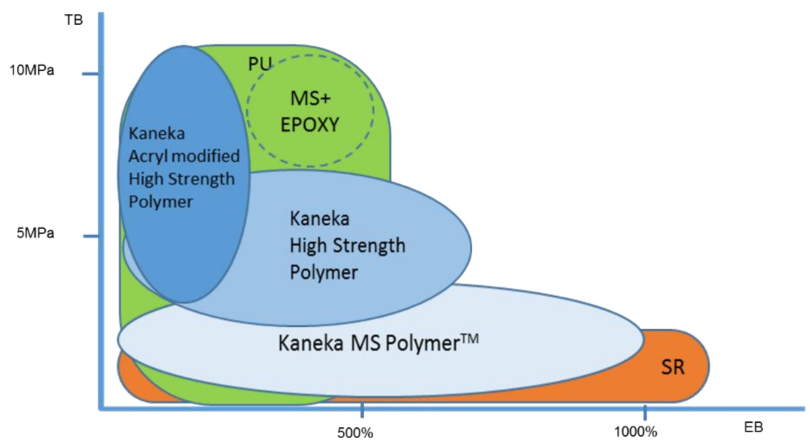


Figure 1 Comparison of the different adhesive technologies with the Kaneka technologies.

With the years of experience in developing polymers a toolbox has been generated which enables to develop custom made polymers for specific adhesive applications. With the unique technology of blending the silane terminated polyethers with silane functional acrylics an outstanding adhesion performance to plastics can be obtained.

The silane acryl modified polymers are polymers with different structure combined in order to control the compatibility and Tg. When the polyether/polyacrylate blend cures, a change in compatibility occurs and a phase separation will happen between the polyacrylate and the polyether parts resulting in homogeneously distributed acrylic and ether domains. The acrylic domains will provide high strength and excellent adhesion to plastics, whereas the ether domains will give elasticity to the cured system.

In the new high strength polymers, the polyether backbone has been modified leading to an increased number of branching points on the backbone, which results in more entanglements and a denser polymer matrix after curing. The increased number of siloxane bonds will provide the higher strength. When these polymers are blended with silane acryl modified polymers, the strength can even be increased to a level of more than 10 MPa (tensile strength at break) in a formulated product. In table 1 an overview of the viscosity and mechanical properties of the acryl modified high strength polymers is given and in table 2 the basic properties of an adhesive formulated with a new high strength polymer are shown. It can be observed that a tensile strength at break of 8 MPa can be achieved and still keeping the elongation at 200%.

Type	Grade	Viscosity (Pa.s)	M50 (MPa)	Tb (MPa)	Eb (%)
Acryl Modified HS	Polymer A-A	50	0,62	4,94	153
	Polymer B-A	140	1,03	5,25	167
	Polymer C-A	150	0,63	8,46	168

Table 1 Overview of the properties of the different acryl modified high strength MS Polymers (All data were obtained by Kaneka Corporate)

Tack free time		hh:mm	0:02
Skin formation time		hh:mm	0:10
Viscosity by rheometer	at 0,1s^{-1}	Pa.s	6819
	at 0,5 s^{-1}		1966
	at 5 s^{-1}		417
	at 10 s^{-1}		298
Hardness	1d/3d/7d 23°C/50%RH		66 74 75
Tear strength (kN/m)	ISO-34-1 method B		15,3
Tensile strength by dumbbell shape	M50	MPa	2,41
7d 23°C/50%RH	M100		4,41
	T_b		8,42
	E_b	%	229

Table 2 Basic properties of an adhesive based on a new high strength MS Polymer™ (All data were obtained by Kaneka Belgium)

Adhesion to plastics

As mentioned earlier, the acrylic part of the acryl modified high strength polymers will provide a better and stronger adhesion to plastics. In figure 2 an overview is given of the lap shear strength of a formulated adhesive based on acryl modified Kaneka MS Polymer™ to a range of unprimed substrates. [6] Depending on the type of plastic the lap shear strength ranges between 2 and 8 MPa, which comes in the range of metals as shown with the example of stainless steel.

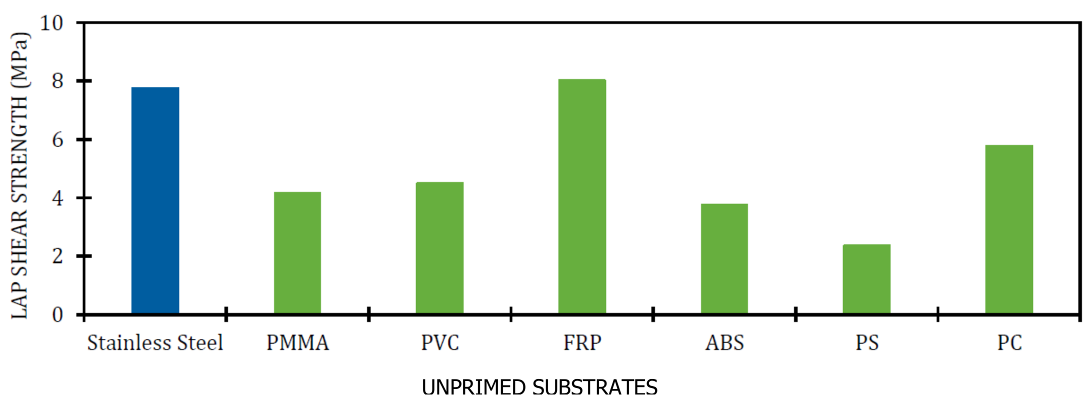


Figure 2 Lap shear strength of an acryl modified MS Polymer™ based adhesive to unprimed stainless steel, polymethylmethacrylate (PMMA), polyvinylchloride (PVC), fiber reinforced polyester (FRP), acrylonitrile-butadiene-styrene rubber (ABS), polystyrene (PS) and polycarbonate. (All data were obtained by Kaneka Belgium)

With the use of more and more plastics the need for so-called hybrid adhesion is increasing. Plastics will have to be adhered to for instance metals, wood, etc. With the high elongation or expansion and low glass transition temperature (Tg) of the MS Polymer^{TM} it will be possible to bond materials with dissimilar thermal expansion coefficients without having the risk of breaking the bonds when temperature changes and this will result in proper hybrid adhesion. In figure 3 an overview of the thermal expansion coefficient of different materials is given with the coefficients of different types of MS Polymer^{TM} grades. The most elastic grades as Kaneka Silyl^{TM} SAX220 are able to cover a wide range of coefficients and adhere different types of materials independent of temperature.

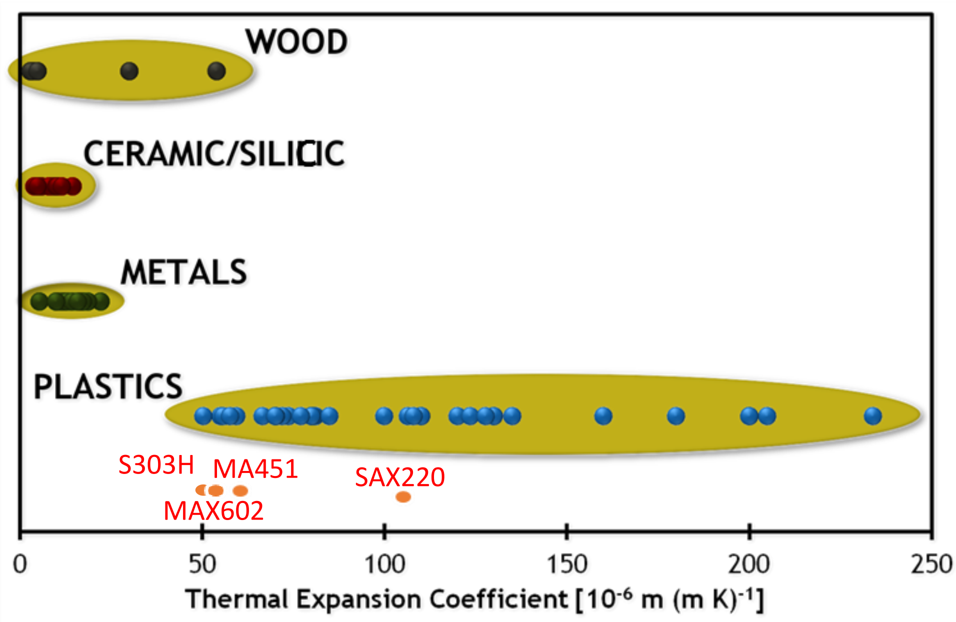
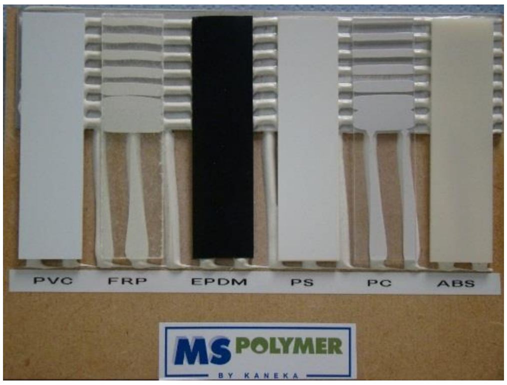


Figure 3 Thermal expansion coefficients of different materials (Data on MS Polymer^{TM} grades were obtained by Kaneka Belgium)

Picture 1 shows an example of one MS Polymer^{TM} based adhesive which adheres different types of plastics and rubbers to fiberwood and aluminum and at the same adhere the wood directly to the aluminum. When only one adhesive has to be used, time and cost will be saved as there is no need to continuously change the adhesive during assembly.



Picture 1 Example of MS Polymer^{TM} based adhesive which adheres polyvinyl chloride (PVC), fiber reinforced polyester (FRP), EPDM, polystyrene (PS), polycarbonate (PC) and ABS on aluminum and fiberwood.

Conclusion

The silane terminated polymers and especially the acryl modified versions, provide a technology enabling the development of adhesives which combine high strength adhesion and excellent adhesion to all different types of substrates and also plastics. Because of this combination, the acryl modified silane terminated polyethers are very suitable for hybrid assemblies in transportation and building applications as materials with dissimilar thermal expansion coefficients can be adhered.

STPE's will become one of the base materials for light weight construction in the future and polymer development will continue to cope with all the upcoming hurdles on assembly of new materials which will be developed in future.

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