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New bondable styrenic block copolymer elastomers

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Septon K is a new series of flexible materials which feature superior adhesion to metal, glass, and various types of resins including polyolefins. These materials exhibit plasticity, elasticity, and mechanical properties similar to existing thermoplastic elastomers. The superior bond ability is obtained via heating without the presence of any primer or pretreatment. In this paper, the characteristics and possible applications of Septon K series are shown.

1. Introduction

Septon is a series of hydrogenated styrenic block copolymers (HSBCs), which consists of styrene-based hard blocks and a hydrogenated diene soft block. HSBCs exhibit rubber elasticity since the hard block acts as a cross-linking point below the glass transition temperature of polystyrene and the soft block provides elasticity. Hydrogenation provides excellent heat and weather resistance.

Major applications of HSBCs are thermoplastic elastomers, adhesives, and polymer modification. TPEs are used for automotive, consumer products widely replacing vulcanized rubber and PVC as a soft molding material. Hot melt adhesives consisting of HSBCs are used for diapers, sanitary napkins, and tapes. HSBCs are added to polymers as impact modifier or compatibilizer.

HSBCs exhibit excellent adhesion properties to non-polar materials such as polypropylene and polyethylene. On the other hand, adhesion to polar materials (glass, metal, polar plastics) is poor, so that pre-treatment is necessary to achieve adhesion to these materials. In order to meet today's demands for improved adhesion properties of HSBCs, Kuraray has developed the Septon K series which features superior adhesion to metal, glass, and various types of plastics including polyolefins. The superior bonding is obtained via heating. The material can be molded without compounding and retains the advantages of styrenic thermoplastic elastomers.

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2. Characteristics of the Septon K series

Adhesion strength was measured by 180° peel test. To prepare the adhesion sample, an elastomer sheet was bonded to a plate by hot pressing for 3 min as demonstrated in **figure 1.** PET sheet was used for backing to prevent the elastomer sheet to be extended and to keep 50 mm/min peel speed. Peel strength values of 20 N/25 mm or more were considered as good adhesion.

2.1 Comparison to other elastomers

Figure 2 shows a comparison of adhesion strength among thermoplastic elastomers. Septon K series shows good adhesion not only to polypropylene, but also to glass, aluminum, and magnesium alloys. Adhesion strength to PP is at the same lev-

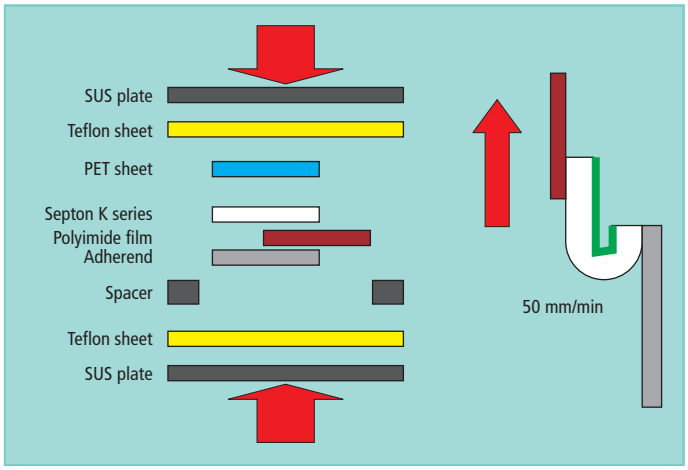


Fig. 1:
Adhesion test method

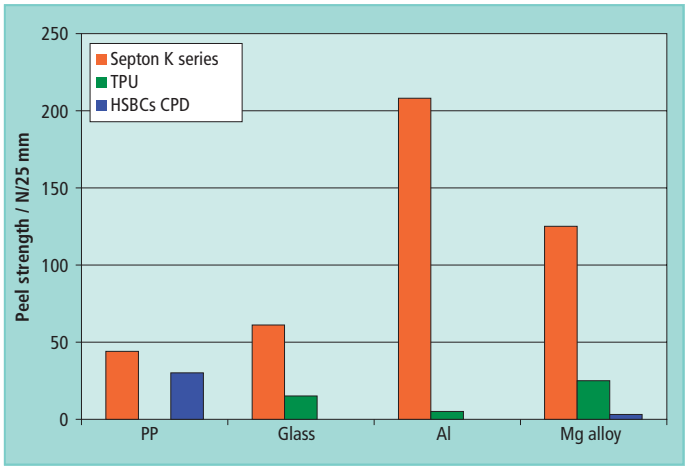


Fig. 2:
Adhesion strength of TPE

el as conventional HSBC compounds. Adhesion strength to polar materials is higher than TPU which has good affinity to these materials.

2.2 Adhesion to metal and glass

Adhesion of the Septon K series is achieved by heating. On the one hand, a lower processing temperature is preferable in order to save energy and to prevent material damage. On the other hand, due to its thermoplastic character, Septon K series only has a limited service temperature. A high service temperature is favorable in order to make the material suitable for demanding applications. We developed three grades with different performance profiles **(fig. 3):**

- KM088 adheres to glass and metal at lower processing temperature.
- KM125 has higher service temperature.
- KM079 is a special soft grade.

Figure 4 shows the adhesive strength to glass as a function of the hot press temperature. Adhesion strength increases at higher temperatures. Required temperature on adhesion to glass of KM088, KM125, and KM079 is 120 °C, 160 °C, and 200 °C respectively.

Figure 5 shows the adhesion strength to glass as a function of the peeling temperature. KM125 shows good adhesion strength over 80 °C and tears before peeling at 100 °C. **Table 1** shows the adhesive strength to metals. Septon K series shows good adhesion to various metals. The effect is similar to glass adhesion.

2.3 Adhesion to plastics

Table 2 shows adhesive strength to plastics. Septon K series exhibits good adhesion to polyolefins similar to conventional Septon based compounds. KM088 strongly adheres to polyethylene. KM125 and KM079 show excellent adhesion to polypropylene. KM125 adheres extremely well to glass fiber reinforced polypropylene. Septon K series also shows good adhesion to various kinds of polar plastics. The required temperature to achieve adhesion depends on the nature of the plastic.

3. General properties

In **table 3** general properties of the Septon K series are listed. Shore hardnesses from 50A to 90A comparable to conventional HSBC compounds are possible. The good elongation values may show that Septon K retains rubber elasticity similar to conventional HSBCs. The flexibility of the material is useful as it can effectively contribute to a reduction of the stress caused by differences of linear expansion between metal and plastic. Additionally, the melt flow rate shows that the flowability of the Septon K series is sufficient for molding applications.

Various technologies are possible to achieve adhesion **(tab. 4).** Press molding can be done with all kinds of adherend materials. For example, by sandwiching a Septon K sheet with steel and aluminum in a hot press process, Al/steel conjugated parts can be produced. Overmolding and co-extrusion are possible, too. Septon K series can for example be extruded with polyolefins and polar plastics. The co-extruded part can be bonded to other materials such as metal and glass. Electromagnetic induction welding can be used for adhesion to metals. By placing molded Septon K on the metal heated by electromagnetic induction welding, strong adhesion is obtained. Laser welding is possible if the adherend is transparent.

Tab. 1: Adhesion to metals

Adherend	KM125	KM088	KM079
Processing temperature / °C	160	140	240
Glass	61	55	128
Aluminum	208	28	129
Magnesium alloy	125	38	125
Steel	133	41	105
Galvanized steel	100	25	24
SUS304	83	49	104
Copper	68	26	86

Fig. 3: Grades of the Septon K series

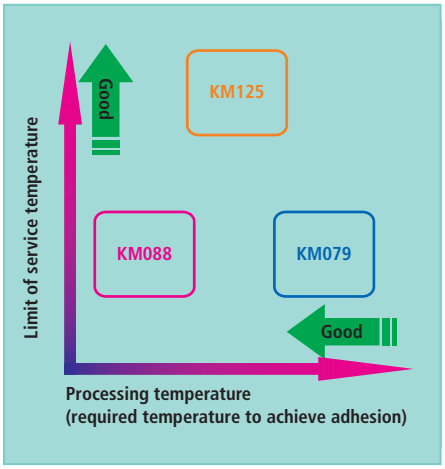


Fig. 4: Effect of processing temperature on adhesion

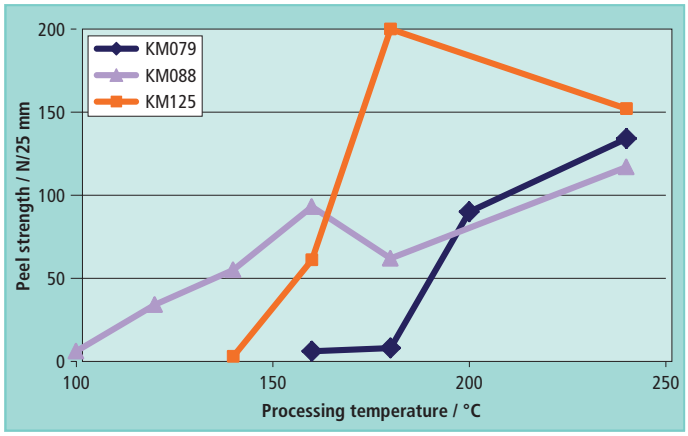
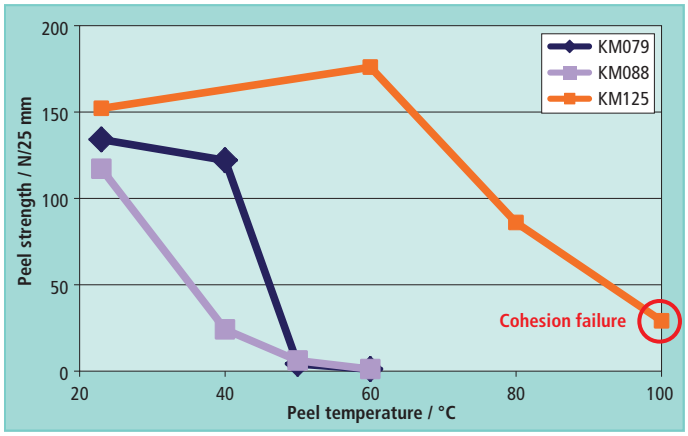


Fig. 5: Effect of peel temperature on adhesion



4. Potential applications

Multi-component parts are often produced by using tapping screws and anchor structures. However such mechanical methods restrict the product design. For example, the use of tapping screws spoils the appearance of the product, and a minimum thickness is necessary in order to prepare anchor structure. Another method to produce multi-component parts is the use of adhesives. However, pretreatment is necessary to combine non-polar to polar materials. Pretreatment methods such as primer coating, plasma and corona treatment makes the production process more complex. Furthermore, conventional rigid adhesives used between plastics to metals often cause adhesion failure, because metals and plastics have different coefficients of linear expansion. Therefore, the stress causes in adhesive layer due to heating and cooling.

Septon K series adheres to both polar and non-polar materials without pretreatment. Therefore, it is expected that it will contribute to flexible product design, manufacturing process improvements, rationalization and total cost reduction as substitutes of tapping screws, anchor structures and pretreatment. Additionally, its elasticity helps to absorb strain caused by differences in linear expansion. Thanks to its adhesion properties and its flexibility, the Septon K series can be used in such fields as automotive, electrical components, energy related components, housing and construction. In the automotive field, the number of applications with aluminum and plastics is constantly increasing in order to save weight. The market of electrical and electronic components also demands flexible design and production process improvement.

Adherend		Processing temperature / °C	KM125 N/25 mm	KM088 N/25 mm	KM079 N/25 mm
Polyolefin	PE	130	41	87	-
	PP	160	44	1	63
	PP-GF30	160	196	8	61
Polar resin	PA6	200	177	-	3
	PBT	210	37	90	18
	ABS	140	6	14	7
	PC	160	32	48	7
	ABS/PC	160	31	39	11
	PPE/PS	160	30	59	86

Tab. 2:
Adhesion to plastics

5. Summary

Kuraray has developed a new family of HSBCs called Septon K series. They have good adhesion properties to non-polar and polar materials. Adhesion is achieved simply via heating; pretreatment is not necessary. Because of its elasticity it balances differences of linear expansion between different materials. The Septon K series enables new ways of designing multi-component parts.

Tab. 3: General properties of the Septon K series

	KM125	KM088	KM079	Method
Hardness / Shore A	83	67	50	ISO7619
Specific gravity	0,92	0,92	0,91	ISO1183
100 % Modulus (TD) / MPa	3,1	1,7	1,1	ISO37
Tensile strength (TD) / MPa	18	5,7	7,8	
Elongation (TD) / %	790	670	830	
MFR (230 °C/2.16 kg) / g/10min	4,6	11	0,7	ISO1133

Tab. 4: Possible adhesion processes with Septon K series

	Glass	Metal	Polyolefin	Polar plastic
Lamination	○	○	○	○
Press molding	○	○	○	○
Overmold Injection	△	△	○	△
Co-extrusion	—	—	○	○
Electromagnetic induction welder	—	○	—	—
Laser welder	○	—	—	△

○: Available △: Available under limited condition