Excellent damping performance at elevated temperatures

Hydrogenated styrenic elastomer Hybrar SV-series

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Lately, the efforts to reduce automotive weight for fuel efficiency has increased the problem of vibration and road noise and led to a reduction in passenger comfort and driving pleasure. The electrification of the automobile has decreased engine noise which was major noise source but other noises such as road noise, wind noise and transmission noise which were hidden by the engine have become more noticeable. As described above, the demand to reduce vibration and noise is increasing and is diversified. Damping materials, which can effectively reduce vibration and noise without significantly increasing the car weight, have been addressed as a countermeasure. Kuraray has recently developed new hydrogenated styrenic block copolymers with excellent damping performance at elevated temperatures. This article describes properties and benefits of the new materials.

1 Introduction

Since in-vehicle noise is present in a wide frequency range of 20 to 20,000 Hz **(tab. 1),** the damping material should exhibit high damping performance over a wide frequency range. However, it is difficult to cover all the temperatures and frequencies since the temperature and the frequency at which the damping properties become effective are determined by the glass transition temperature (T_g) of the damping material. One method is using damping material which has damping properties at the temperature and frequency of vibration and noise which we want to suppress in particular. The other method is using multiple damping materials in combination which can suppress vibration over a wide temperature and frequency range.

So far, materials exhibiting damping properties at room temperature or low temperature range are widely used, but there are only a few examples of materials exhibiting high damping properties at temperature ranges exceeding room temperature. The Hybrar SV-series can be expected to be a solution that can achieve high damping performance at higher temperatures.

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All figures and tables, unless otherwise stated, have been kindly provided by the authors.

2 Structure and characteristics of Hybrar

Styrenic elastomers, which are a type of thermoplastic elastomer (TPE), consist of (a) polystyrene block(s) as hard segments and a polybutadiene and/or polyisoprene block as soft segments. This kind of polymer exhibits rubber-like properties since hard segments act as physical crosslink points below

Tab. 1: Frequency ranges of automotive vibration and noise [1]

Frequency in Hz	Source
20–100	Booming noise at low or middle speed
100–200	Booming noise at high speed
100–600	Road noise
100–5,000	Tyre pattern noise
200–3,000	Engine noise
300–2,000	Noise of differential gear
1,000–20,000	Brake noise
2,000–10,000	Wind noise

Fig. 1: Structure of hydrogenated styrenic block copolymers (HSBC)

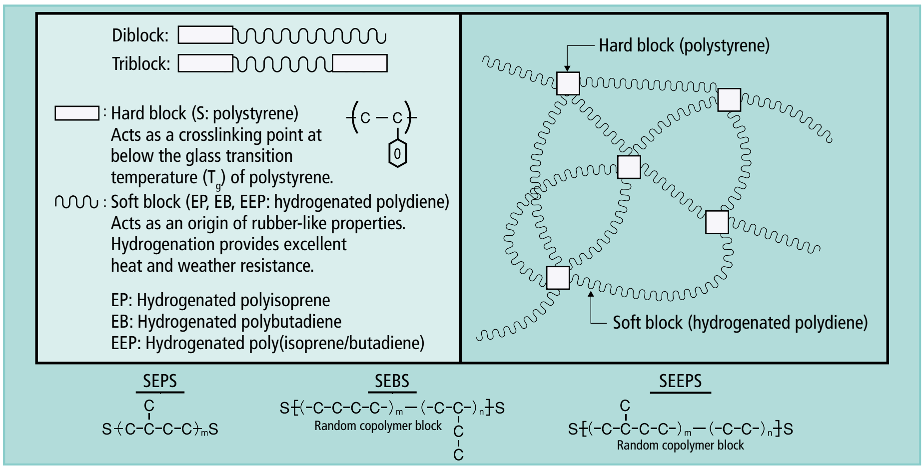
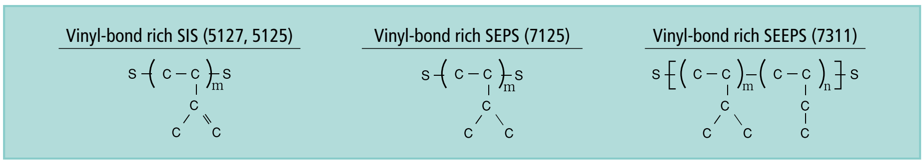


Fig. 2: Structure of Hybrar



the glass transition temperature, yet it flows and is processable at temperatures higher than the T_g. When the polydiene block is hydrogenated, it is called a hydrogenated styrenic elastomer or hydrogenated styrenic block copolymer (HSBC) **(fig. 1).**

HSBCs have many advantages in comparison to non-hydrogenated styrenic copolymers including:

- higher tensile strength,
- better heat resistance,
- better weather resistance,
- better ozone resistance,
- better compatibility with polyolefins.

HSBCs are classified in terms of the soft segment structure, namely SEBS, SEPS and SEEPS. Hybrar has a higher T_g compared to general HSBCs thanks to a higher vinyl content (higher 1,2-bonding and 3,4-bonding) in their polydiene block. Because of this structure, Hybrar has higher damping properties near room temperature **(fig. 2).** Adding Hybrar gives improved damping properties to various resins, engineering plastics and rubbers such as polyolefins, polystyrene, ABS, EVA, TPV, and EPDM.

3 Styrenic elastomer Hybrar SV-series

Hybrar 5127, which has highest T_g (8 °C) amongst the traditional Hybrar grades, shows excellent damping properties near room temperature. However, it has lower heat resistance and weather resistance compared to hydrogenated grades due to its non-hydrogenated structure. For the modification of engineering plastics, high heat resistance is important in order to avoid decomposition while compounding at high temperatures. As a result, Hybrar 5127 is not the best damping modifier for engineering plastics. On the other hand, the T_g of Hybrar 7125 (-7 °C) which has a hydrogenated polydiene block does not quite match the damping properties near room temperature.

To solve this problem, Kuraray developed two kinds of novel polymers by utilizing its well-defined anionic polymerization and hydrogenation technology. Hybrar SV-series 7318 has a similar T_g to Hybrar 5127 despite having a hydrogenated polydiene block. Since Hybrar SV-series 7119 has the highest T_g (20 °C) amongst commercial grades of HSBC, it is expected to show excellent damping properties above room temperature.

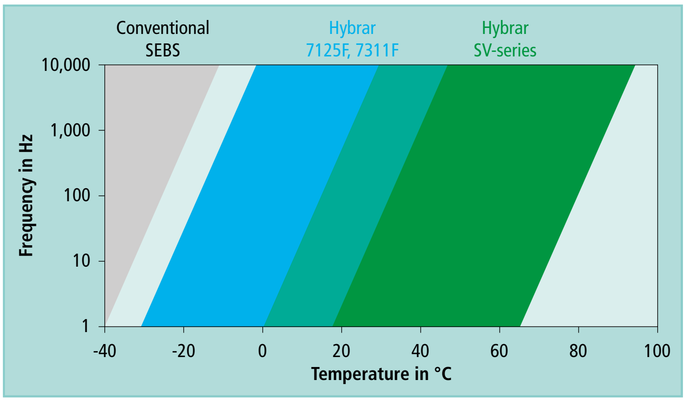


Fig. 3: The conceptual scheme for the frequency and temperature conditions where each grade of HSBC has damping properties

Figure 3 shows the conceptual scheme for the area of frequency and temperature where each HSBC provides damping properties. Hybrar SV-series can achieve excellent damping properties even at higher temperatures and/or lower frequencies compared to traditional hydrogenated Hybrar grades. It is expected that it can achieve damping properties at a wider range of temperatures required for automotive applications when blended with traditional Hybrar grades **(tab. 2).**

4 Dynamic viscoelastic property of the Hybrar SV-series

The temperature dependence of the loss tangent (tan δ) for all Hybrar grades as measured by viscoelasticity testing is shown in **figure 4.** When comparing traditional SEBS, all Hybrar grades have a higher tan δ value at 0 – 40 °C. Hybrar SV-series 7318 has the same peak tan δ temperature as Hybrar 5127, which has highest peak tan δ temperature of current Hybrar grades. Hybrar SV-series 7318, however, is hydrogenated and has a higher tan δ value and wider tan δ bandwidth than Hybrar 5127. On the other hand, Hybrar SV-series 7119 has the highest peak tan δ temperature of 33 °C. It results in a lower damping property at room temperature but excellent damping property at 40 – 80 °C. The frequency dependence of the loss tangent at several temperatures as calculated by WLF model is shown in **figures 5** and **6.** At 20 °C, Hybrar SV-series 7318 has a high tan δ value below 1,000 Hz. At 40 °C, it has a high tan δ value between 1 Hz and 100,000 Hz and Hybrar SV-series 7119 has a high tan δ at values below 100 Hz. Choosing the right Hybrar grade according to the operating conditions of temperature and/or

Tab. 2: Typical properties of Hybrar

	Hybrar grade	Type (vinyl-bond rich)	Styrene content in wt%	Peak temperature of tan δ in °C	Glass transition temperature in °C	Hardness in Shore A	MFR in g/10 min		Physical form
							230 °C, 2.16 kg	190 °C, 2.16 kg	
Hydrogenated	SV-series 7119	SEPS	12	33	20	96	15		Pellet
	SV-series 7318	SEEPS	12	13	4	65	1		Pellet
	7125F	SEPS	20	–7	–15	64	4	1	Pellet
	7311F	SEEPS	12	–22	–32	41	2	1	Pellet
Unhydrogenated	5127	SIS	20	15	8	84		5	Pellet
	5125	SIS	20	–8	–13	60		4	Pellet
Measurement method				Tested by DMA	DSC (temperature increase by 10 °C/min)	ISO 7619 as reference	ISO 1133		

frequency will result in exceptional damping materials.

5 Dynamic viscoelasticity property of ABS/Hybrar SV-series blends

The temperature dependence of the loss factor on blends of Hybrar and ABS is shown in **figure 7.** The loss factor is another indicator of damping property in addition to the loss tangent (tan δ). Blending 10 % Hybrar SV-series 7318 with ABS significantly increases the loss factor value at 2,000 Hz at 20 – 60 °C.

On the other hand, blending in 10 % of Hybrar SV-series 7119 increases the loss factor value at a higher temperature range of 40 – 80 °C. As shown in **table 3,** the blending of soft TPE with ABS decreases the stiffness (flex modulus). If the ABS/Hybrar is blended with filler, however, it will maintain its stiffness and result in an increased damping property.

6 Conclusions

In this paper we showed that the use of Hybrar SV-series can lead to better damping properties at high temperature ranges. This will allow processors, through the use of both the Hybrar SV-series and general Hybrar grades, to manufacture excellent damping materials which can be used to make products for the automotive, sporting, construction and electrical appliance markets which require a wide service temperature range.

7 References

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Tab. 3: Mechanical properties of ABS CPD

TPE species	Neat ABS	SV-series 7119	SV-series 7318	5127	7125F	SEBS
ABS	100	90	90	90	90	90
TPE	0	10	10	10	10	10
Mechanical properties						
Tensile strength in MPa	51	45	42	44	42	42
Elongation at break in %	12	12	16	15	16	23
Tensile modulus in GPa	2.7	2.2	2.2	2.3	2.2	2.3
Flexural strength in MPa	96	79	76	75	76	78
Flexural modulus in GPa	2.9	2.4	2.4	2.4	2.4	2.5
Charpy impact strength in kJ/m²	2.6	2.2	2.6	1.2	2.7	4.5
Measurment temperature of mechanical properties: 23 °C						

Fig. 4: Temperature dependency of tan δ of Hybrar

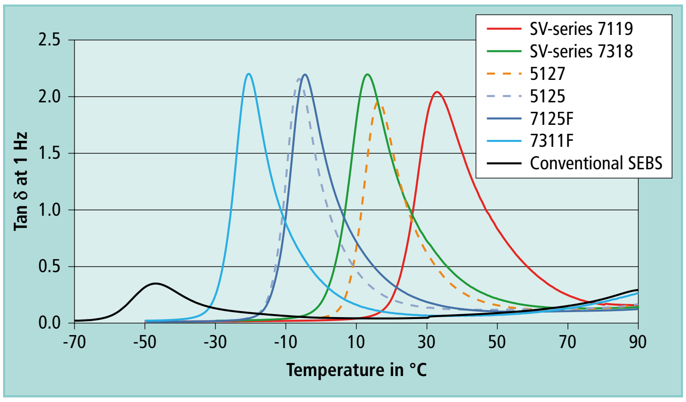


Fig. 5: Frequency dependency of tan δ of Hybrar (reference temperature 20 °C)

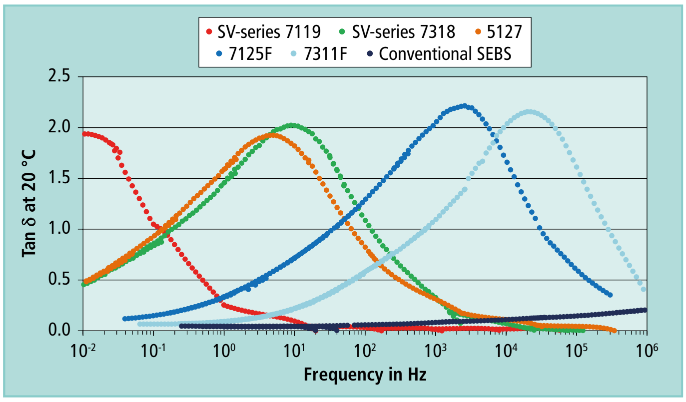


Fig. 6: Frequency dependency of tan δ of Hybrar (reference temperature 40 °C)

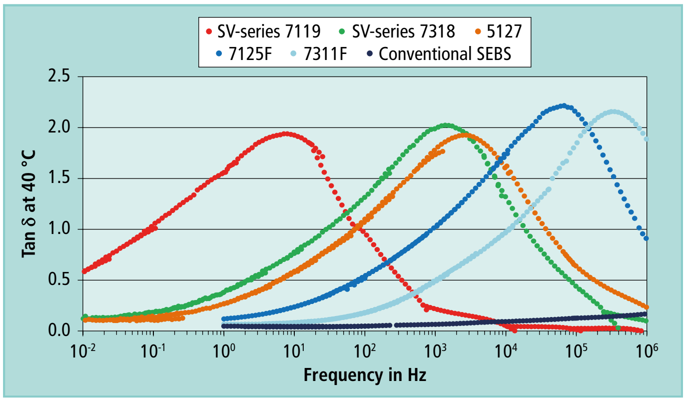
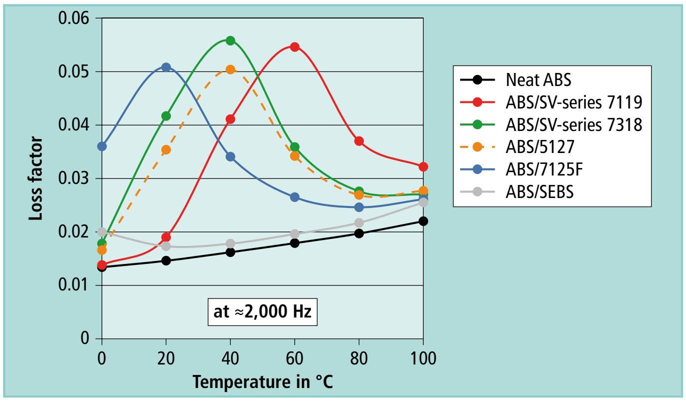


Fig. 7: Temperature dependency of loss factor of ABS/Hybrar CPD (ABS/Hybrar = 90/10, by wt)



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