Shock Absorbing Material

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1 Abstract

We have found out that material with weak three-dimensional cross-linking in the structure shows response to shear stress. Furthermore, we developed a shock absorbing material utilizing the network structure. The newly developed material absorbs shock better than the conventional material with a network structure of covalent bonds.

2 Characteristics of the New Product

- Has a three-dimensional cross-linking network structure with weak bonds.
- Shows stimulation response to shear stress.
- Shows shock absorption.

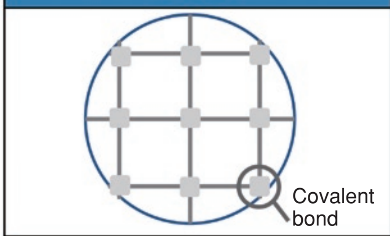
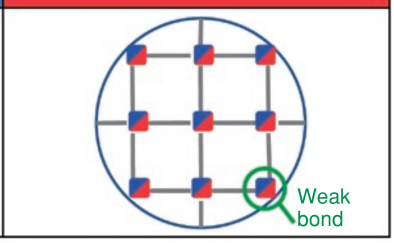
3 Background of the Development

As part of the development of biomimetic materials, we proceeded with the research and development of novel industrial materials focusing on the fact that biological materials, such as DNA and proteins, express responses to stimulation that utilizes weak hydrogen bonds.[1] During this process, we developed materials that introduced a three-dimensional cross-linking network structure with weak bonding energy between the molecules of polymer chains to discover the expression of the response to shear stress. We found that stimulation response technology is useful for alleviating shock force in addition to shear stress, so we developed the shock absorbing materials reported below.

4 Technical Details

Materials such as acryl base resins and silicon base resins with low elasticity are conventionally used as shock absorbing materials. These resin materials have a three-dimensional cross-linking network structure with covalent bonds. In contrast, products developed by reference to biological materials have the feature of having a three-dimensional cross-linking network structure that uses low energy bonds (**Table 1**).

Table 1 Network structure of conventional and developed material

Conventional material	Developed material
	

The relationship between the storage elastic modulus and shear stress was evaluated to investigate the response of developed materials to shear stress (**Figure 1**).

As a result, it was found that the storage elastic modulus of the developed material was lowered by a shear force at around 10,000 Pa or more. On the other hand, the storage elastic modulus of conventional materials showed almost constant values without relating to shear stress. These results indicate that only the developed material shows stimulation responses where the elastic modulus varies depending on the shear stress. In addition, it was estimated that the developed material expresses stimulation response, because a three-dimensional cross-linking network with weak bonds collapsed under high shear stress.

Based on the above results, we hypothesized that a stimulation response technology can be established by considering not only shear stress, but also shock force, and applied this developed material to shock absorbing sheets to conduct drop weight tests. In these tests, balls were obliquely dropped on a film made of the developed material, the colored area on pressure sensitive paper was assumed to relatively correspond to the intensity of shock absorbing energy, and it was evaluated that the smaller the relative value, the better the shock absorption (**Figure 2** and **Table 2**).

The developed material showed results where the value at point A was lower than that of the conventional material and the coloring of pressure sensitive paper was not found at point B, meaning that the shock absorption of the developed material exceeded that of the conventional material. It was considered that the conventional material absorbed the shock by deformation of the material caused by the dropping ball, while the developed material showed shock absorbability owing to the breakage of weak bonds at the same time of material deformation (**Figure 3**).

Hereafter, we will further proceed with the development of materials focusing on the deployment to various shock absorbing and stimulation response-related fields by taking advantage of the moderate network structure.

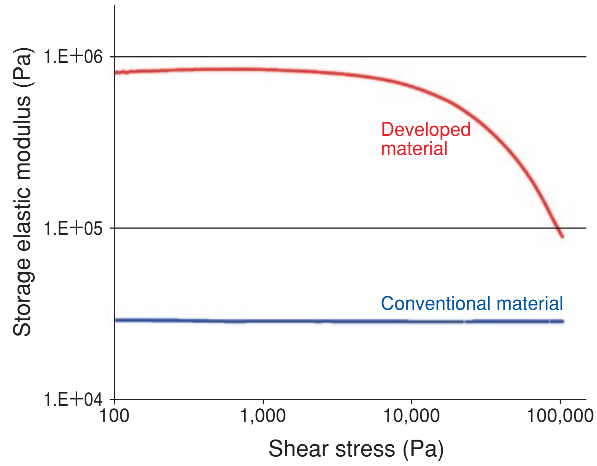


Figure 1 Relationship between modulus of elasticity and shear stress

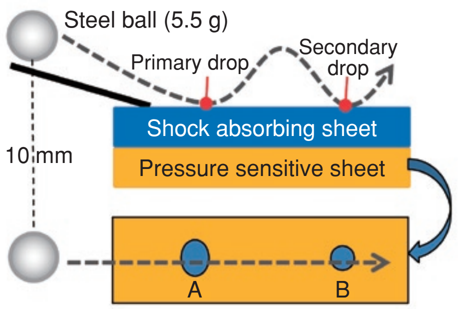


Figure 2 Method of the drop weight test

Table 2 Result of the drop weight test

Measuring point	Conventional material	Developed material
A	100	89
B	32	0

・The smaller the value, the higher the shock absorption.

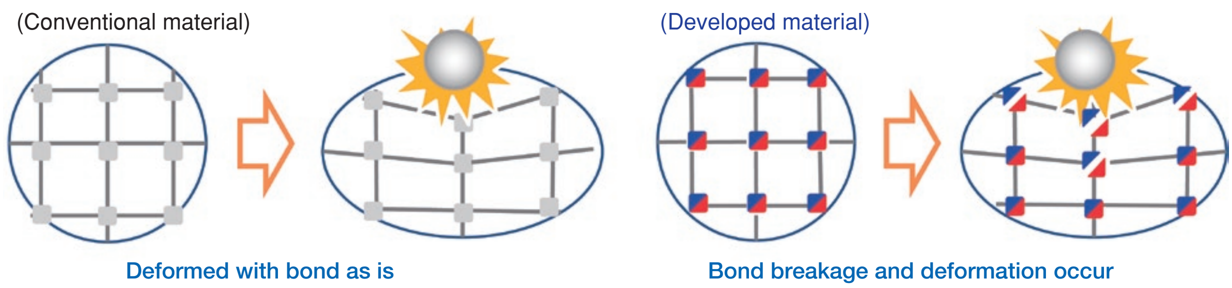


Figure 3 Speculated mechanism when shocked

5 Future Business Development

・Deploy into shock-absorbing fields
・Explore new applications

【Reference】

1) A. Yoshida, N. Takahara,"A new optical clear adhesive material for next generation display", Material Research Society 2016, EP-14 (2016).