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Characterization of carbon black added liquid target used in laser-induced stress wave devices

レーザ誘起応力波素子に用いるカーボンブラック添加液体ターゲットの特性評価

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1 Introduction

We have already studied on gene transfection using laser induced emergent stress waves (LIESW) [1]. So far, we reported that higher pressure was generated by LIESW devices using thin laser target [2]. The limitation of target thickness was however revealed [3]. On the other hand, minimum requirement of pressure (15 MPa) due to foreign substance transfer was realized by using carbon black (CB) suspension as target [4]. This report discusses fabrication and characterization of CB added liquid target.

2 Experimental procedure

2.1 Light source and sensor

A 532 nm Q-switched Nd:YAG pulse laser (Spectra Physics, LAB130, pulse width, 10 ns, max energy 0.2 J) was used as laser source. An LIESW is generated by laser irradiation to target, and then propagates in water of dish attached on a target. The pressure in water is measured by using hydrophone sensor (Muller-Platte Needle Probe, tip diameter: 0.5 mm or less). Optical system and detail of LIESW device should refer to our reports [1, 4].

2.2 Method of CB dispersion and evaluation

The method of cracking and dispersion of CB was chosen factitious or plasma treatment. Factitious treatment was carried out by cracking of a mortar and pestle. **Figure 1** shows a fabrication process of this method. In plasma treatment, CB was processed for 720s by plasma powder installation (Sakigake semiconductor, PPU-800). The distribution of CB particle size was analyzed by laser diffraction particle size analyzer (Shimadzu, SALD2300).

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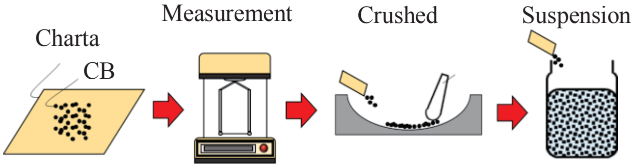

Fig. 1 Fabrication process of factitious treatment.

3 Results and discussion

3.1 Acoustic signature of LIESW

The LIESW device, factitious CB-20%-added adhesion and 1mm-thick-polyethylene terephthalate (PET), was directly bonded on TC dish. To determine the target thickness, a spacer of thickness 110 μm with the hole of 6 mm in diameter was arranged at the center of TC dish. **Figure 2** shows typical acoustic signatures of the pressure wave using several LIESW devices. The peak pressure, pressure gradient, and impulse momentum are shown in **Table 1**. Although peak pressure when using CB added adhesives (solid and liquid) were lower than those when using conventional (EPDM 0.07mm) devices [4], pressure gradient was small only when using liquid adhesive. It was also found that the result of impulse momentum was as well as that of peak pressure. These parameters obtained from acoustic signatures depend on the states and structures of target, the profiles of these acoustic signatures however seem to be similar.

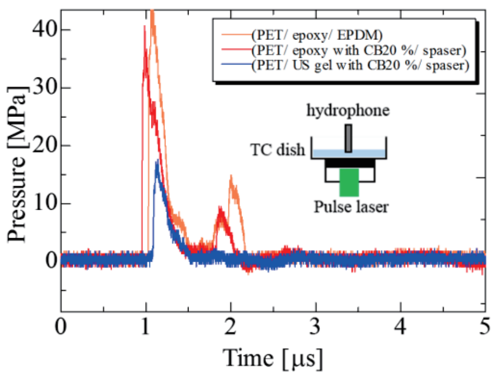

Fig. 2 Acoustic signatures by several LIESW devices.

Table 1 Summary of pressure, pressure gradient, and impulse momentum.

Material	Pmax±SD [MPa]	Gradient±SD [MPa/ns]	Implse±SD [Pa・s]
EPDM0.07 mm (*n*=1)	46.3	1.3	11.2
Solid (*n*=3) (Epoxy with CB)	37.8 ± 3.2	1.1 ± 0.1	8.6 ± 0.8
Liquid (*n*=3) (US gel with CB)	15.0 ± 3.0	0.3 ± 0.2	3.7 ± 0.1

3.2 Characterization of CB added liquid target

Figure 3 shows typical particle size distribution of CB added pure-water, in which two dispersion methods (factitious and plasma treatments) are used. CB consistency was fixed at 6% in both treatments. Frequency and integration show abundance ratio to the subject particle size and cumulative distribution of frequency, respectively. Through the verification by statistical examination, no significant difference from the results in the factitious treatment is confirmed. It was found from Fig.3 that average particle size using plasma treatment was smaller than that using factitious treatment.

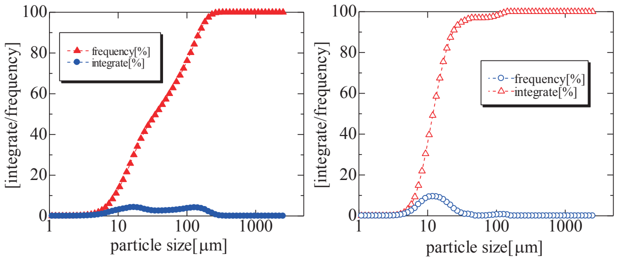

Fig. 3 Particle size distribution of when used of different dispersion treatment.
(left : factitious treatment, right : plasma treatment)

Figure 4 shows a magnified view of the frequency distribution shown in Fig. 3. **Table 2** shows the results analyzed by using data processing software (Shimadzu, WingSALD). The average CB particle size was ranged from 10 to 20 μm by plasma treatment. This result was small in comparison with average CB particle size (38.7 μm) subjected to factitious treatment.

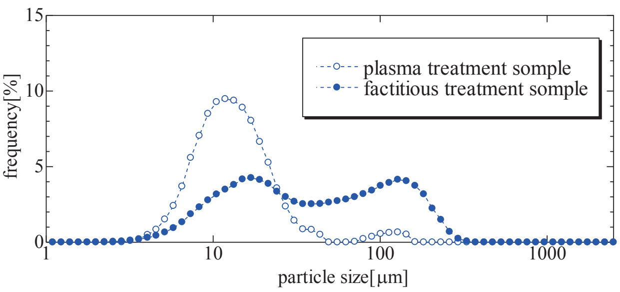

Fig. 4 The comparative of particle size distribution at different dispersion treatment method.

Table 2 The comparative of average particle size.

Technique	Average particle size ± SD [μm]
Factitious (*n*=5)	38.7 ± 2.5
Plasma	10 - 20

In this experiment, Denka black (DENKI KAGAKU KOGYO) with large amount of carbon (>99 %) was used as CB. The hydrophobic is therefore high because less hydrogen as a functional group is existed. The hydrophobicity of factitious treatment does not improve due to these powder properties of the CB. On the other hand, the hydrophobicity was increased by plasma treatment, because CB surface became hydrophilic by increasing with the adhesion by chemical functionality, and with surface energy due to the accumulation charges [5]. Therefore, the particle diameter of the plasma treated sample became small. That is, it is considered that stable dispersion of CB is realized by applying a plasma treatment.

4 Conclusion

The peak pressure, pressure gradient, and impulse momentum when using CB added liquid target were revealed. Average CB particle size in factitious liquid target was approximetely 40 μm. Furthermore, it is also planed to measure the acoustic characteristics of CB added liquid target.

Acknowledgment

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