Pis'ma v ZhETF, vol. 119, iss. 4, pp. 263 – 264

Enhancement of terahertz radiation from saccharide solutions induced by femtosecond laser pulses

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Submitted 7 December 2023
Resubmitted 6 January 2024
Accepted 6 January 2024

DOI: 10.31857/S1234567824040025, EDN: szniis

Liquid is a promising candidate for terahertz radiation induced by femtosecond laser pulses, since it has advantages of higher molecular density, lower ionization potential and better self-healing properties compared with gases [1]. To achieve a better radiation performance, optimization approaches such as two-color excitation schemes [2], double-pulse excitation schemes [3] have been proposed. It is noteworthy that the electric field of terahertz radiation in air plasma can be enhanced with 10 times by changing excitation conditions from single-color scheme to two-color scheme. While in liquid water, however, enhancement with only 11 % can be achieved [4]. Since improvements of laser conditions have limited influence on terahertz radiation, exploration of better liquid medium is another way to optimize the performance of terahertz sources.

In this work, an enhancement of terahertz radiation from saccharide solutions induced by femtosecond laser pulses is demonstrated, and the characteristics of terahertz radiation from saccharide solutions of different types and concentrations are investigated. The trends of radiated terahertz power as a function of pump laser power for saccharide solutions including starch solution, maltose solution, sucrose solution, and glucose solution are shown in Fig. 1a. From the Figure 1 it is found that the starch solution shows the best terahertz radiation property. Maltose solution and sucrose solution radiate terahertz waves with approximately the same radiant power. Glucose solution radiates the weakest terahertz waves. Different kinds of saccharide have diverse molecular structures and different relative molecular masses, which are responsible for the different radiation properties. Glucose is a monosaccharide with a relative molecular mass of 180.16. Sucrose and maltose belong to disaccharides and have a relative molecular mass of 342.30. Starch is a polysaccharide and the relative molecular mass of it is higher than the disaccharide. It can be inferred that saccharide solutions with a higher relative molecular mass tend to radiate stronger terahertz waves.

The influence of solution concentration on terahertz radiation is investigated in the subsequent experiments. As shown in Fig. 1b, terahertz radiations from four kinds of saccharide solution increase at the beginning. The fastest rate of increase is observed for polysaccharides (starch), followed by disaccharides (maltose and sucrose), and the slowest is for monosaccharides (glucose). Therefore, Starch reaches the optimum value first and then begins to decline. It is followed by maltose and sucrose which reach their maximum values at 30 %. No maximum value for glucose is observed within researchable range. In the first phase, the increasing concentration of saccharide and density of solution are responsible for the upward trend. However, when the concentration reaches a certain level, a good liquid flow can hardly be obtained because of the viscosity changes, and ultimately leads to a decrease in radiated power after the maximum value. Therefore, it can be inferred that the dependences of terahertz raidation on solution concetration is a combined effect of solution density and liquid viscosity. It should be noted that the viscosity of the saccharide increases as its concentration increases, resulting in its inability to form a good liquid line. Therefore, the concentration range can be investigated in this study is 0–35 % for glucose, maltose and sucrose, while with only 0–10 % for starch.

Funding. This research was funded by the National Natural Science Foundation of China (61971208), Yunnan Fundamental Research Projects (202301AV070003), Major Science and Technology Projects in Yunnan Province (202302AG050009), the Key Research and Development Program of Guangdong Province (# 2019B090917007), and the Science and

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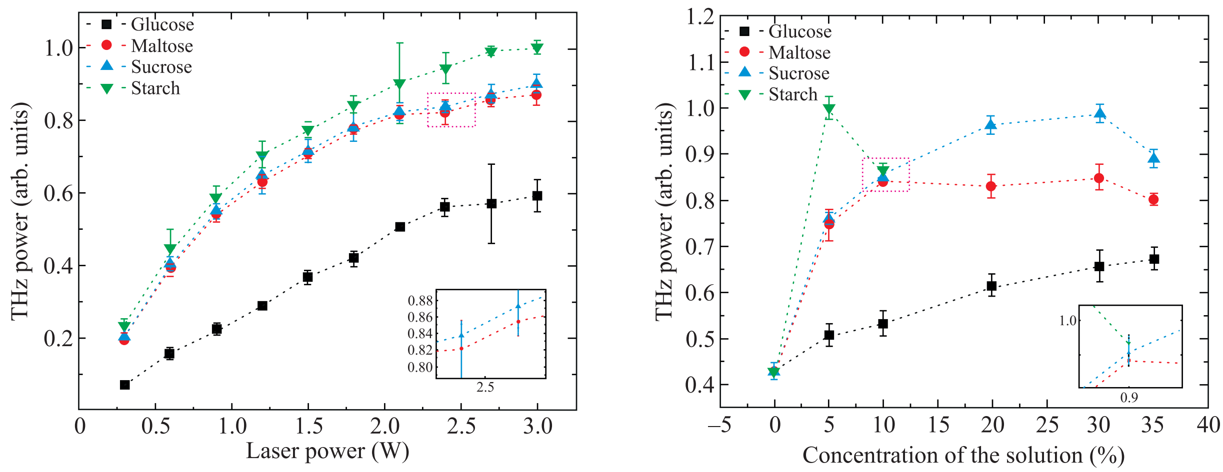

Fig. 1. (Color online) Experimental results of terahertz radiation from different saccharide solutions as a function of: (a) – laser power and (b) – solution concentration

Technology Planning Project of Guangdong Province (# 2019B090909011).

Conflict of interest. The authors declare that they have no conflicts of interest.

This is an excerpt of the article “Enhancement of terahertz radiation from saccharide solutions induced by femtosecond laser pulses”. Full text of the paper is published in JETP Letters journal. DOI: 10.1134/S0021364023603949

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