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Atomization of various solutions using SAW devices

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1. Introduction

Surface acoustic waves (SAWs) are waves propagating on the surface of an elastic material. When a liquid is loaded on the SAW propagation surface, the longitudinal wave is radiated from the SAW. When the amplitude of the SAW is increased, nonlinear phenomena, that are droplet oscillation, transportation, small droplet ejection, and so forth, are observed. This is called SAW streaming[1)]. When a liquid thin film is formed on the surface, an atomization occurs by the SAW and the mist is ejected[2, 3)]. In previous research, we experimentally discussed the frequency dependence of the atomization[4)]. The SAW atomization is driven at high frequencies, leading to power savings. It also has the advantage that it can be used around electronic products because the mist diameter is smaller than that of low-frequency atomizers and does not wet the surrounding area. However, the mechanism of atomization by SAW is not clear, and the relationship between atomization volume and humidity was determined for humidification and chemical spraying as further industrial applications of SAW atomizers.

2. Experimental procedure

An interdigital transducer (IDT) was fabricated on 128YX-LiNbO3 single crystal. The SAW device was placed on top of a water-holding container and water was continuously supplied using filter paper. The experimental setup is shown in **Fig.1.** A humidity sensor was installed in the sealed system, and humidity changes over time were measured using an Arduino UNO. The SAW device was excited by the burst signal, which is generated from continuous and pulse signals in Fig. 1. Input power was varied by the RF power amplifier. Used solutions were distilled water and different concentration of ethanol solution. The developed SAW atomizer was placed on an electronic scale and an atomization experiment was carried out. The amount of water reduced by atomization was measured with an electronic scale. Filter paper was changed after each measurement. At least three experiments were performed under the same conditions.

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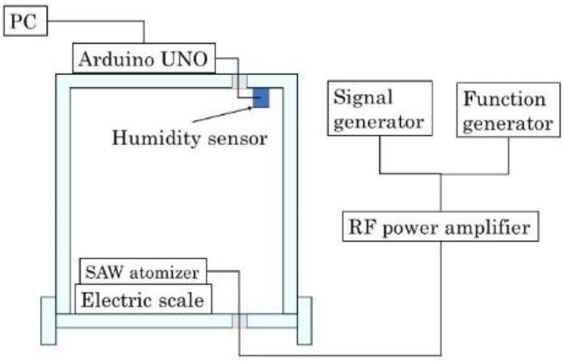


Fig.1 Schematic of experimental setup.

3. Results and discussion

Weight reduction of water due to atomization was measured at 5-minute intervals. The result is shown in **Fig.2**. The amount of water reduction during SAW excitation is greater than that during natural evaporation (0W). This is a reasonable result. However, the amount of water reduction was greater when the input power of the SAW device was 1.2W than when it was 3W. We have considered this to be due to the large variation in the amount of water reduction from one measurement to another.

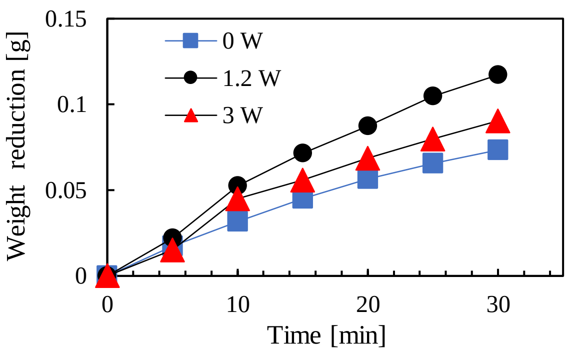


Fig. 2 Water reduction by atomization versus time.

Next, the effects of humidity and the amount of water reduction by atomization were examined. The effects of ethanol solution as well as water were also examined. **Fig.3** shows the relationship between humidity and the amount of water reduction ratio per minute. For 1.2 W, we see that the weight reduction ratio per minute is zero when the humidity is 40 Rh%. On the other hand, at 3W, the weight reduction per minute increases as the humidity increases. It is reasonable to assume that an increase in the amount of water loss leads to an increase in humidity.

Atomization experiments were also conducted for ethanol solutions, and the results of the relationship between humidity and the weight reduction ratio of the ethanol solution per minute are shown in **Fig. 4**. The weight reduction ratio of the ethanol solution tends to decrease with increasing humidity. This is a different result from that for water. The reason for this is thought to be that ethanol is more easily volatilized.

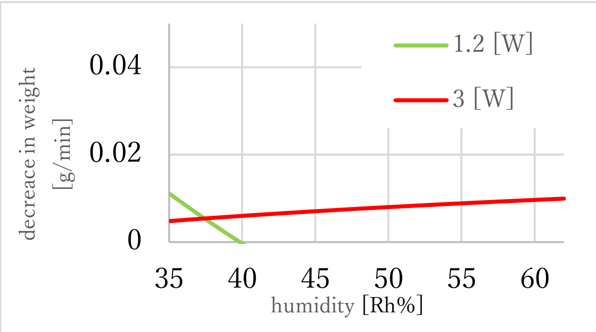
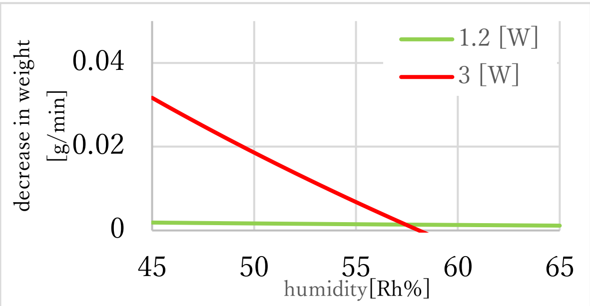
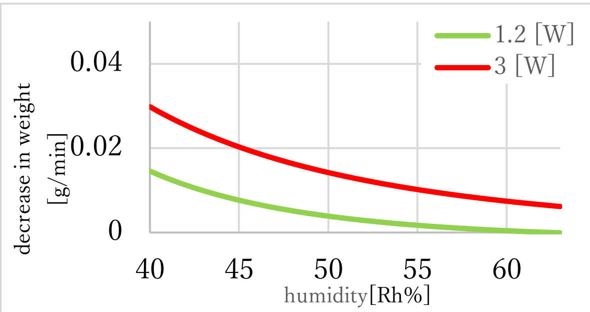


Fig. 3 Relationship between humidity and weight reduction ratio for water.



(a)



(b)

Fig. 4 Relationship between humidity and weight reduction ratio for water for ethanol solution of (a) 5 vol.% and (b) 15 vol.%.

Fig.5 shows that the results varied considerably depending on the central frequency. Most of the data showed an increase in humidity in proportion to the amount of decrease, but only the data for atomization at 3[W] with 5[vol%] ethanol showed little change in humidity, although the amount of decrease was large. This result suggests that the concentration of the solution before atomization and the mist after atomization may have changed.

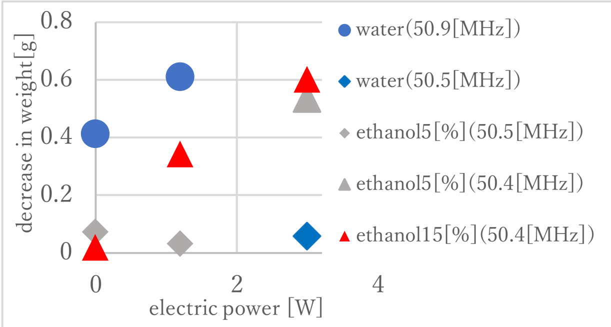


Fig. 5 Relationship between input power and weight reduction for water and ethanol solution. The frequency was set to the optimum value for each experiment. ●: Water (50.9 MHz), ◆: water (50.50MHz), ◆: ethanol 5 vol% (50.5 MHz), ▲: ethanol 5 vol% (50.4 MHz), ▲: ethanol 15 vol% (50.4 MHz).

4. Conclusion

The results of this experiment indicate that ethanol atomization is possible. It was also found that the amount of atomization varied greatly depending on the device's center frequency. The device with the highest atomization increased humidity by approximately 10[%], suggesting that humidification is possible if an optimized device is used. For application to chemical spraying, changes in concentration before and after atomization need to be investigated in the future.

References

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