Ultrasound absorption on aqueous solution of non-ionic polymers constructing via hydrogen bond networks/
水素結合ネットワークを含む非イオン性ポリマー水溶液の超音波吸収

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<Introduction>
Nowadays ultrasound (US) technology has been applied widely in many fields such as cleaning industries, health diagnosis and several industries. Many studies about US effect on water soluble polymers has been carried out with absorption of a high frequency (0.2 – 2 MHz), but only a few works in a low frequency (20 – 100 kHz). The ultrasound absorption has been studied for different kind of polymers PAA, PAAM, NIPAM. In the present study, we examined ultrasound absorption in aqueous solutions of non ionic polymers with the interest to substantiate the US effect on interactions of non-ionic polymer solutions. The measurement for the effects of US absorption in polyvinyl alcohol (PVA) was performed according to a model of sound absorption.

<Experimental and Methods>
The degree of saponification of PVA (Kuraray Co.) was 87% and the weight- average degree of polymerization (DP) was 1700. The polymer was used without further purification. The PVA was dissolved in distilled water at 80 °C with stirring. After homogenization, the PVA solution was gradually cooled to room temperature. Analysis of ultrasound absorptivity was performed as shown in Fig. 1. The PVA solution placed in a polypropylene (PP) cell (60ml) was set in water bath of US equipment, which was used in the present experiment was Ultrasonic Multi Cleaner W115 (Honda Electronics Co., Ltd). Fig. 1 shows side view of the water bath of the cleaner. A stainless steel cleaner equipped with a dimension of 30×30×30 (cm³) attached with 7 pieces of transducers having 3 cm diameter in side wall of the ultrasonic water bath, which were connected to the side wall of the water bath. The operated US frequencies were 28, 45 and 83 kHz with the intensity controlled by controller in the range of 175-300 W. In order to estimate the sound intensity in the water US bath, a sound detector probe (V301; Panametrics Japan Co).

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Abstract:
The ultrasonic velocity of propagation and absorption coefficient characteristic of aqueous solutions of macromolecules are of interested in the field of physical chemistry. Ultrasound (US) absorption in aqueous polyvinyl alcohol (PVA) solution was investigated. The US waves were emitted at three different frequencies of 28, 45 and 83 kHz. The intensity passed through a medium containing PVA, by varying it’s concentration in the solution; the intensity that it absorbs was measured. The results showed that at the US at 45 kHz, PVA can absorb the ultrasound, but more studies will need to do, in order to analyze if breakage of the hydrogen bonding occurs.

Scheme 1. Chemical structure of PVA.
the different concentration of the aqueous solution, the detected signal intensity \( (V) \) was displayed as a function of time in the oscilloscope. The transmitted US intensity in the aqueous solution was measured as \( I_0 \) and \( I_{PVA} \) without and with PVA, respectively. Transmittance was calculated as \( T = \frac{I_{PVA}}{I_0} \). Then, the calculated values of \( T \) were determined changing the PVA concentrations (g/L). Ultrasound absorptivity (A) of the US was defined as

\[
A = -\log (T) = \varepsilon_{US} LC
\]

Here, \( C \) was concentration of PVA and \( L \) was length of the cell (3 cm), where the PVA solution was present, \( \varepsilon_{US} \) was constant (m²/g), meaning that molecule area of the US absorption per unit weight.

**Results and Conclusion**

Fig. 2 shows relationship between \( A \) and \( C \) (g/L) for the US system of 28, 45 and 83 kHz. As observed in the values of \( A \), there was tendency of the US absorption on increasing in the high concentration of PVA. It is noted that the relation of \( A \) and \( C \) was observed from their plots. We evaluated the value of \( \varepsilon_{US} \) at each frequency to estimate the slope of the plots. The value of \( \varepsilon_{US} \) was 272, 574, and 446 m²/g for 28, 45 and 83 kHz, respectively. The value at different frequencies as shown can be seen that there is trend. Absorption coefficient become to be high at 45 kHz for decreasing the PVA solution and can also observed the maximum absorption occurs at the frequency of 45 kHz.

To conclusion, the US absorptivity was analyzed using absorptivity coefficient (\( \varepsilon_{US} \)) of the US. It was confirmed that the 45 kHz US was effective for the measurement of the value of the US absorptivity. The PVA molecules adsorbed US highly when the frequency was 45 kHz. However, it can not conclude that the absorbed US seemed to convert the chemical change of the PVA in the hydrogen bond in these polymer chains.

**Reference**