At the beginning of the presentation, I want to introduce you some concept of emulsion.

There are four types of emulsions:

O/W emulsion (oil dispersed in water),

W/O emulsion (water dispersed in oil),

These two types are known as simple emulsions.

O/W/O emulsion and W/O/W emulsion (small droplets within large droplets).

These two types are known as multiple emulsion or double emulsion.

Alright, let's focus on the estimation of the volume fraction of a simple emulsion.

Firstly, we need a viscosity model that takes into account the volume fraction of the emulsion. One such model is Pal's model.

Where μr is relative viscosity of emulsion，

λ is viscosity ratio between the dispersed phase and continuous phase.

And Φ is the volume fraction.

Φm is the maximum volume fraction at which droplets do not deform or squeeze each other out of shape, as the right picture. And it’s related to the distribution of the droplets size.

The right-hand side of the equation is identical to the model used for particle suspension. Therefore, we can derive the emulsion model based on the existing particle suspension model. The figures at bottom shows that models in this form can well predict the viscosity of emulsions.

Next, in order to simplify the equation, we make the assumption that the emulsion consists of only two sizes of droplets, as shown in the right picture.

The size ratio between the larger droplet and the smaller droplet is either 5 to 1 or 20 to 1. The figures at the bottom shows the relationship between the predicted viscosity, the volume fraction and the distribution of droplet size. We consider the X-axis as a simplified distribution the droplets size.

It can be observed that the lines is nearly horizontal when the volume fraction is below 30 percent. Hence, I think it can be concluded that the viscosity is almost independent of the droplet size distribution when the volume fraction is below 30 percent.

Next, by setting a constant droplet size, the Φm also becomes a constant.

Thus, the two-parameter model is simplified into a one-parameter model, enable us to derive the equation into this form.

In this equation. Theλ has already known. So if we can measure the μr, we can calculate the volume fraction.

For example, we can use ultrasonic velocity profiling to measure the flow information in real-time.

By analyzing this flow information, we can calculate the viscosity of the emulsion.

In the end, with the viscosity, we can calculate the volume fraction by using this equation.

In this part, we used a model based on Roscoe's equation. The figure at bottom shows the viscosity values measured using an ultrasonic spinning rheometer at different volume fractions. The emulsion behaved like a Newtonian fluid at low shear rates, consistent with the model’s description.

the figure on the right compared the experimental and estimated volume fraction values at different viscosities. I found that this method can well estimated the volume fractions between 15% and 30%.

However, there was a large error at 10% volume fraction. I consider that this error was caused by inaccuracies in the rheometer. Because the gradient is steep at this point.