The influence of the emulsion composition on the wettability of the emulsion

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Abstract. In order to explore the influence of the emulsion composition on the wettability of the emulsion, using lauric acid polyoxyethylene esters (LAE) and polyethylene oleic acid diester (DQA) as the emulsifier and oleic acid ester (QA) as the smoothing agent, the spinning emulsion system with the content of smoothing agent above 30% was prepared. The results show that: with the increase of emulsion concentration, the surface tension of emulsion, the contact angle of emulsion on the surface of the polypropylene fiber and the wetting time of canvas in emulsion all decreases. At the same time, the emulsion has critical micelle concentration, when the concentration is less than CMC, the surface tension of emulsion, the contact angle of emulsion on the surface of the polypropylene fiber and the wetting time of canvas in the emulsion decreases rapidly with the increase of the emulsion concentration, while it’s more than this concentration, the influence of emulsion concentration on the three kinds of nature is smaller. Besides, the increase of the mass fraction of the smoothing agent and the increase of the compound emulsifier HLB will result in worse wettability.

1. Introduction
Wetting is one of the basic properties of microemulsion, during the spinning process, fibers in high-speed drafting, the need for oil quickly and evenly spread to the fiber surface, so as to fully protect the fiber, otherwise, oiling will occur uneven, partially oil-free, large friction, spinnability decreases, so wetting is very important for spinning and processing [1].

The surface tension directly affects the contact angle and the length of the wetting time. Under normal circumstances, the lower the surface tension of the oil is better for wetting permeability of the fiber and oiling effect [2]. There are many ways to determine the surface tension of liquids, such as hanging drop method, deprotection method, bubble pressure method, drop volume method, hanging film method, drop method, capillary rise or fall and so on [3].

After emulsifying the oleate with a single emulsifier, the spin finish has poor effect. The emulsion determined in this paper is mainly composed of the existing surfactants, such as smoothing agents and emulsifiers. The contact angle between the emulsion and the polypropylene fiber was measured by the appearance image analysis method and the wettability was characterized by the hydrophobic fiber [4].
Using the national standard method to initially explore the emulsion concentration and composition of the impact on wettability, in a certain range of spinning oil emulsification can provide some reference.

2. Experimental section

2.1. Experimental materials and instruments
Polyoxylethylene laurate LAE (HLB value = 13.1), polyethylene glycol oleate DQA (HLB value = 10.5), Oleate QA, Tianjin Textile Textile Auxiliary Co., Ltd.
FA2004N electronic balance, Shanghai Jinghai Instrument Co., Ltd. production; JB-2 temperature magnetic stirrer, Shanghai Lei Magnetic New Jing Instrument Co., Ltd. production; DSA25 automatic contact angle measuring instrument, the German company Klv; JYW- 200 automatic surface tension meter, Chengde heyday experimental instrument factory.

2.2. Experimental methods

2.2.1. Emulsion preparation
The emulsifiers LAE and DQA were respectively mixed in different quality proportions of 2: 8, 3: 7, 4: 6 and 5:5 to form a complex emulsifier (represented by C), and the emulsifier C and smooth QA were mixed at different concentrations, of which QA accounted for 30%, 35%, 40% and 60% respectively. Afterwards, water was added and mixed well to prepare emulsions of different concentrations and allowed to stand at room temperature for 24 hours.

2.2.2. Determination of surface tension, contact angle and wettability
The surface tension of the emulsion is measured after being calibrated by absolute ethanol or distilled water at room temperature of 20°C. The densitometer is used to measure the density of the solution and the actual surface tension of the tested oil sample is calculated according to the formula [2].

The contact angles of pure water (concentration 0%) and different concentrations of emulsion on a single polypropylene fiber were measured at 20°C at room temperature using a DSA25 automatic contact angle measuring instrument. Each measurement was averaged five times.

Preparation of a certain concentration of oil emulsion 900mL. Will configure the emulsion at 20°C constant temperature conditions, the use of "surfactant wetting power measurement immersion method" (GB/T 11983-2008) will be submerged in the canvas canvas was measured in the concentration of the emulsion, record Run Wet time, corresponding to the concentration of the emulsion and the ratio of draw wetting curve, can evaluate the impact of the wettability of the emulsion.

3. The results and discussion

3.1. The effect of emulsion concentration on wettability

3.1.1. The contact angle and surface tension
It can be seen from figure 1, compared with pure water, the contact angle of the emulsion on the polypropylene fiber significantly reduced. And under the same emulsion ratio, the contact angle between emulsion and polypropylene fiber decreases with the increase of emulsion concentration. This shows that the experiment of ester-type microemulsion in the fiber on the spread of a very significant increase. This is because emulsion micelles can significantly reduce the surface tension of water as shown in figure 2, making it easier to spread on the hydrophobic fibers. And the higher the concentration of disperse, the smaller the liquid surface tension, the more obvious spread of the emulsion on the fiber.
Figure 1. The change of contact Angle of emulsion and fiber along with concentration about three kinds of emulsion with different proportions.

At the same time, it can also be seen from figure 1 that there is a mutation point (1.0% concentration) in the curve of contact angle with concentration. The concentration at this point can be regarded as the critical micelle concentration (CMC) of the emulsion. The contact angle of the emulsion on the PP fiber decreased rapidly with the increase of the concentration, and the influence of the emulsion concentration on the contact angle decreased gradually after the concentration was increased. This is because the emulsion before reaching the critical micelle concentration by the surfactant in the emulsion, the surface tension decreased rapidly to reach the critical micelle concentration of the emulsion, the concentration continues to increase, the emulsion began to form a large number of plastic oil The degree to which the surface tension of the emulsion decreases will begin to slow as shown in figure 2.

From figure 1 and figure 2, we can see that the contact angle between emulsion and PP fibers is directly related to the surface tension of emulsion, which also confirms the Young's equation: \[ \gamma_s = \gamma_{sl} + \gamma_{li} \cos \theta \] describing the relationship between contact angle and surface tension. From Young's equation, it can be seen that the smaller the surface tension of liquid is, the smaller the contact angle is when the surface tension of the solid is constant.

3.1.2. The wettability

It can be seen from the experiment that the wetting time of the emulsion and the canvas is related to the change of the concentration as shown in figure 3 (a) and figure 3 (b): The wetting time of cloth in pure water is much longer than the wetting time in the emulsion. As the emulsion concentration increases, the wetting time becomes shorter. And when the emulsion concentration is small, as shown in figure 3 (a), the wetting time is rapidly shortened as the emulsion concentration increases. However, when the emulsion concentration exceeds a certain level (about 0.7% in this paper), As shown in figure 3 (b), the wetting time is still shortened as the concentration increases, the wetting time decreases with increasing concentration.

Figure 3. The change of wetting time with concentration of emulsion.
The reason why the wetting rate of the canvas is much larger than that of the water is because a small amount of spinning oil can obviously reduce the surface tension of the water as shown in figure 3. And when the emulsion concentration is small (less than 0.7%), the surface tension of water decreases rapidly with increasing concentration, while the concentration of more than 0.7%, the rate of surface tension decreases slowly. So there will be a turning point in figure 3 (a) wetting time with concentration changes. It should be noted that, although the rate of slowing, but there are still changes, the same trend. In addition, there is a slight concentration difference between the turning point of the wetting time and the turning point of the surface tension, which may be due to the difference of the solid-phase interfaces measured by the two during the test: The canvas sedimentation method uses canvas when wetting time, its hydrophilic strong, and the measurement of contact angle using a hydrophobic polypropylene fiber, the two interface surface properties vary greatly, resulting in the concentration of these two sets of curves obtained by a certain difference.

3.2. The effect of emulsion composition on contact angle and wettability

3.2.1. The effect of emulsifier ratio on contact angle and wettability

The change of HLB value is caused by the change of the ratio of emulsifier LAE and DQA. The bigger the ratio of LAE to DQA is, the larger the HLB value is. When the QA content is 45% and the emulsion concentration is 1%, the contact angle between emulsion and polypropylene fiber at different HLB and the wetting time of canvas in the emulsion are measured. The results are shown in figure 4. As the HLB value of emulsifier increases Large, contact angle and wetting time are gradually increased, and almost linear relationship.

![Figure 4](image1.png)  ![Figure 5](image2.png)

**Figure 4.** The change of contact Angle and wetting time with the size of HLB under the same ester content (45%). **Figure 5.** The change of contact Angle and wetting time with the ester content under the same proportion of emulsifier(LAE:DQA =3:7).

Emulsifier can reduce the surface tension between liquid and solid, surface tension drop will lead to the spread of the emulsion on the fiber better, wetting the canvas faster. The single emulsifier lipophilicity and hydrophilic properties have focused. Therefore, the use of a single emulsifier can reduce the surface tension, but its stability is not strong. The composite emulsifier generally contains both hydrophilic and lipophilic emulsifier, it can greatly reduce the surface tension. In order to obtain the best results, we need to mix different emulsifiers, hydrophilic emulsifiers and lipophilic emulsifiers by adjusting the content to balance the hydrophilic emulsifier, lipophilic properties [5].

Different dispersed phases, the continuous phase mutual emulsification, the required HLB values are generally different, and the same dispersed phase, continuous phase required HLB value theoretically should be a fixed value. However, the choice of different emulsifiers for compounding, due to the nature of the different emulsifiers, there may be some deviation [6]. In the experimental
range of this paper, the greater the HLB value of the composite emulsifier, the poorer the effect of reducing the surface tension of the emulsion. The larger the contact angle between the emulsion and the polypropylene fiber, the longer the wetting time of the canvas in the emulsion. In addition, the HLB value not only reflects the ratio of emulsifier, but also reflects the size of the hydrophilic base mass of the composite emulsifier. When the hydrophilic mass fraction is larger, the relative lipophilicity will be relatively smaller. Most of the organic synthetic fibers such as polypropylene fibers show hydrophobic-lipophilic properties, so the more hydrophilic hydrophilic emulsion in the fiber the greater the contact angle.

3.2.2. The effect of ester content on contact angle and wettability
When the emulsifier LAE: DQA = 3: 7, the emulsion concentration is 1%, the contact angle between the emulsion and the polypropylene fiber and the wetting time of the canvas in the emulsion under different ester contents were measured. The results are shown in figure 5: The contact angle and wetting time all increased with the increase of ester content, close to the linear relationship.

In a certain concentration and emulsifier ratio, the emulsifier can reduce the liquid surface tension between the liquid [7], the surface tension drops will lead to the spread of the emulsion in the fiber becomes better, but also make the emulsion easier to wet the fiber, canvas gets wet faster in the emulsion. In this experiment, when the emulsion concentration is the same, the greater the QA mass fraction of the lubricant, the lower the concentration of the emulsifier and the lower the surface tension, so the contact angle between the emulsion and the polypropylene fiber and the wetting time of the canvas in the emulsion are therefore greater.

4. Conclusion
Dispersions of the emulsion significantly reduce the surface tension of the emulsion, thus greatly reducing the contact angle between the emulsion and the polypropylene fiber and also greatly enhancing the wettability of the emulsion. And the emulsion surface tension and contact angle, wettability changes with concentration there is a clear turning point, that there is an emulsion critical micelle concentration: less than the critical concentration, the surface tension of the emulsion, the contact angle of the surface of the polypropylene fiber and The wetting time decreased rapidly with the increase of the emulsion concentration, and the effect of the emulsion concentration on the surface tension, the contact angle and the wettability became smaller after exceeding this concentration. At the same smoothing agent level, the greater the HLB value of the emulsifier, the greater the contact angle of the emulsion, the poorer the wettability. At the same emulsifier ratio, the higher the content of the smoothing agent, the larger the contact angle of the emulsion and the poorer the wettability. However, in the range of less than the critical micelle concentration, the influence of these two factors on the wettability is much smaller than the variation of the emulsion's own concentration on the wettability.

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