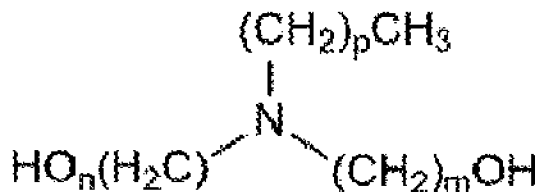




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 (72) Inventeurs/Inventors:
 YIN, HONGYAO, CN;
 FENG, YUJUN, CN
 (73) Propriétaire/Owner:
 SICHUAN UNIVERSITY, CN
 (74) Agent: BLANEY MCMURTRY LLP

(54) Titre : FLUIDE DE DEGIVRAGE/ANTIGIVRAGE D'AERONEF EPAISSI PAR UN TENSIOACTIF D'AMINE D'ALCOOL ALKYLE ET SON PROCEDE DE PREPARATION
 (54) Title: AIRCRAFT DEICING/ANTI-ICING FLUID THICKENED BY ALKYL ALKANOLAMINE SURFACTANT, AND PREPARATION METHOD THEREOF



(57) **Abrégé/Abstract:**

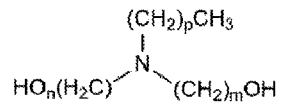
The present invention provides an aircraft deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant, and a preparation method thereof. The aircraft deicing/anti-icing fluid includes the following components, in mass percentage: 27% to 66% of alcohol, 32% to 72% of deionized water, and 0.4% to 2.0% of surfactant. The surfactant is at least one of alkyl alkanolamine surfactants with a structure having the following general formula.

(see above formula)

wherein n is 1 to 5; m is 1 to 5; p is 15 to 21; and n, m and p are all integers.

ABSTRACT

The present invention provides an aircraft deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant, and a preparation method thereof. The aircraft deicing/anti-icing fluid includes the following components, in mass percentage: 27% to 66% of alcohol, 32% to 72% of deionized water, and 0.4% to 2.0% of surfactant. The surfactant is at least one of alkyl alkanolamine surfactants with a structure having the following general formula.



wherein n is 1 to 5; m is 1 to 5; p is 15 to 21; and n, m and p are all integers.

AIRCRAFT DEICING/ANTI-ICING FLUID THICKENED BY ALKYL ALKANOLAMINE SURFACTANT, AND PREPARATION METHOD THEREOF

TECHNICAL FIELD

The present invention relates to the field of deicing and anti-icing, and in particular, relates to a deicing/anti-icing fluid used for the outer surface of an aircraft, and a preparation method thereof.

BACKGROUND

In cold and humid air, it is common to find accumulation of ice and/or snow on the surface of a parked aircraft. The added ice or snow increases the weight of the aircraft, roughens the surface of the aircraft, which causes an increased drag and reduces the lifting force during take off. This tends to cause flight accidents, posing a serious threat to flight safety. Therefore, as specified in international aviation standards, the accumulated ice and snow on the surface of an aircraft must be removed before the aircraft takes off. A variety of deicing methods have been developed for removing the ice and snow that are accumulated on aircraft surface, such as mechanical deicing, electric heating deicing, and application of anti-icing materials. Currently, using an aircraft deicing fluid, especially non-Newtonian deicing/anti-icing fluid, is the most widely-used and effective way. In addition to effectively remove the accumulated ice and snow on the surface of an aircraft, Non-Newtonian deicing/anti-icing fluid also prevent the surface of the aircraft from being frozen within a certain period of time. Presently, in international aviation, a non-Newtonian deicing/anti-icing fluid is generally prepared by thickening a mixture of alcohol/water with water-soluble polymers, including synthetic polymers and natural polymers, c.g., polyacrylic acid (PAA) and derivatives thereof, xanthan gum, guar gum and cellulose. Although the deicing/anti-icing fluid that are sprayed on the surface of an aircraft, would mostly likely be blown off when the aircraft undergoes high-speed flight, a small amount will remain on the aircraft, some relatively-hidden in the areas of wings and elevators. These residual polymer liquids easily form hydrogels, thereby causing hidden troubles to the flight safety. Moreover, the existing deicing/anti-icing fluids usually undergo high-speed shearing during the preparation, transportation, and operation, which results in a certain degree of degradation of polymer molecular chains, thereby reducing the

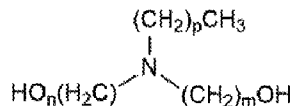
performance of the deicing/anti-icing fluid.

Remarkably reducing or even avoiding the use of polymers in aircraft deicing/anti-icing fluids is an effective way to solve the above problems. Chinese patent CN105199671A discloses an anti-icing fluid thickened by an oligomeric cationic surfactant and a preparation method to obtain an anti-icing fluid based on an oligomeric cationic surfactant. However, the cationic surfactant used can increase the viscosity to obtain a non-Newtonian anti-icing fluid described above only works at high concentration and under the addition of inorganic or organic salts. The addition of salts tremendously increases the potential risk of corrosion on the surface of an object, and tends to cause the instability of the anti-icing fluid system, thereby compromising the safety of use. Chinese patent CN106883819A discloses "a deicing/anti-icing fluid based on an ultra-long-chain viscoelastic surfactant and a preparation method thereof", where an aircraft deicing/anti-icing fluid thickened by an ultra-long-chain surfactant is obtained. However, it requires the surfactant to be synthesized artificially using a complicated preparation process, and calls for an expensive raw material, namely, an ultra-long-chain organic acid. In addition, the surfactant needs to be used at a high concentration, which further increases the cost of the deicing/anti-icing fluid.

SUMMARY

The present invention is intended to provide an aircraft deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant and a preparation method thereof in view of the shortcomings of the prior art, which can overcome the problem that conventional deicing/anti-icing fluids are prone to form hydrogels on the surface of an aircraft and cause corrosion on the surface of an aircraft. The deicing/anti-icing fluid of the present invention has the advantages of stable performance while requires simple preparation and low cost.

The present invention provides an aircraft deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant, including the following components, in mass percentage: 27% to 66% of alcohol, 32% to 72% of deionized water, and 0.4% to 2.0% of surfactant. The surfactant is at least one of alkyl alkanolamine surfactants with a structure having the following general formula.



In the general formula, n is 1 to 5; m is 1 to 5; p is 15 to 21; and n, m and p are all integers.

In the above technical solution of the present invention, the alkyl alkanolamine surfactant is preferably *N*-octadecyl diethanolamine.

In the above technical solution of the present invention, the alcohol is at least one of alkyl diol with 2 to 5 carbon atoms and alkyl polyol with 2 to 5 carbon atoms. The alkyl diol is preferably ethylene glycol, 1, 2-propylene glycol or 1,3-propylene glycol; and the alkyl polyol is glycerol.

The present invention provides a deicing/anti-icing fluid used by aircrafts that is thickened by an alkyl alkanolamine surfactant, preferably including the following components, in mass percentage: 29% to 65% of alcohol, 34% to 70% of deionized water, and 0.4% to 1.5% of alkyl alkanolamine surfactant.

The present invention provides a method for preparing the deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant described above, including: mixing deionized water and alcohol, and thoroughly stirring the resulting mixture; and adding an alkyl alkanolamine surfactant at room temperature, and stirring the resulting mixture until the surfactant is completely dissolved.

In the present invention, the surfactants are all existing compounds, which are commercially available.

The present invention has the following beneficial effects comparing to the prior art.

1. The surfactant in the deicing/anti-icing fluid of present invention is commercially available, and because it is a nonionic surfactant without any ionic head group in the molecular structure, it does not corrode metals, plastics and the like, and it is safe to use.

2. The deicing/anti-icing fluid of the present invention requires a low concentration

of surfactant, resulting in low cost.

3. The deicing/anti-icing fluid of the present invention does not include polymers, which effectively reduce the risk of forming hydrogel.

4. The freezing point of the deicing/anti-icing fluid of the present invention can be adjusted by adjusting the ratio of alcohol to water, and the minimum freezing point can reach -51.0°C , leading to a wide application range.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.47 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/ethylene glycol at different temperatures according to Example 5.

FIG. 2 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.44 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/glycerol at different temperatures according to Example 6.

FIG. 3 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.90 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/glycerol at different temperatures according to Example 7.

FIG. 4 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.88 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/glycerol at different temperatures according to Example 8.

FIG. 5 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.66 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/glycerol at different temperatures according to Example 9.

FIG. 6 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 1.31 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/glycerol at different temperatures according to Example 10.

FIG. 7 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.49 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/1, 2-propylene glycol at different temperatures according to Example 11.

FIG. 8 is a graph illustrating the relationship between the shear rate and the viscosity of the solution of 0.49 wt% *N*-octadecyl diethanolamine in a mixed solvent of water/1,3-propylene glycol at different temperatures according to Example 12.

FIG. 9 shows the anti-icing effect of the deicing/anti-icing fluid composed of 0.44 wt% *N*-octadecyl diethanolamine and water/glycerol on an aluminum substrate (a), a glass substrate (b), and a plastic substrate (c) according to Example 13.

DETAILED DESCRIPTION

The deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant and the preparation method thereof disclosed in the present invention is further described below through examples.

In the following examples, the surfactants and alcohols used are all available at reagent companies on the market.

Example 1

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	47.05
Alcohol: Ethylene glycol	52.48
Surfactant: <i>N</i> -octadecyl diethanolamine	0.47

Preparation: Adding Ethylene glycol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

As measured according to Petrochemical Industry Standard of the People's Republic of China (SH/T 0090-91), this deicing/anti-icing fluid has a freezing point of

-40.3°C, indicating that the deicing/anti-icing fluid of the present invention has a relatively-low freezing point and can work in most extremely-cold environments.

Example 2

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	48.90
Alcohol: 1, 2-propylene glycol	50.61
Surfactant: <i>N</i> -octadecyl diethanolamine	0.49

Preparation: adding 1, 2-propylene glycol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

As measured according to Petrochemical Industry Standard of the People's Republic of China (SH/T 0090-91), this deicing/anti-icing fluid has a freezing point of -36.6°C, indicating that the deicing/anti-icing fluid of the present invention has a relatively-low freezing point and can work in most extremely-cold environments.

Example 3

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	48.54
Alcohol: 1,3-propylene glycol	50.97

Surfactant: <i>N</i> -octadecyl diethanolamine	0.49
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Preparation: adding 1,3-propylene glycol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

As measured according to Petrochemical Industry Standard of the People's Republic of China (SH/T 0090-91), this deicing/anti-icing fluid has a freezing point of -30.4°C, indicating that the deicing/anti-icing fluid of the present invention has a relatively-low freezing point and can work in most extremely-cold environments.

Example 4

In this example, four deicing/anti-icing fluid are prepared according to the following formulas:

Component	Parts by mass (100 parts in total)			
Deionized water	69.72	53.80	43.80	34.25
Alcohol: Glycerol	29.35	45.30	55.32	64.89
Surfactant: <i>N</i> -octadecyl diethanolamine	0.93	0.90	0.88	0.86

Preparation: adding Glycerol to deionized water at room temperature according to the amount in each formula, add *N*-octadecyl diethanolamine according to the amount in each formula, stir the resulting mixtures separately until the *N*-octadecyl diethanolamine was completely dissolved to obtain deicing/anti-icing fluids.

As measured according to Petrochemical Industry Standard of the People's Republic of China (SH/T 0090-91), the above four deicing/anti-icing fluids have freezing points of -9.5°C, -21.0°C, -31.8°C and -51.0°C, respectively, which indicates that the freezing point of the deicing/anti-icing fluid of the present invention can be

adjusted to meet the requirements of use in most environments.

Example 5

In this example, the components of the deicing/anti-icing fluid, the content of each component, and the preparation method were the same as those in Example 1.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity of the deicing/anti-icing fluid and the shear rate at -20°C, -10°C, 0°C, 10°C, and 20°C. As shown in FIG. 1, the deicing/anti-icing fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the deicing/anti-icing fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. In addition, the zero-shear viscosity of the deicing/anti-icing fluid increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 6

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	43.99
Alcohol: Glycerol	55.57
Surfactant: <i>N</i> -octadecyl diethanolamine	0.44

Preparation: adding Glycerol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity and the shear rate at -20°C, 0°C, and 20°C. As shown

in FIG. 2, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. Moreover, the zero-shear viscosity of the deicing/anti-icing fluid significantly increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 7

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	53.80
Alcohol: Glycerol	45.30
Surfactant: <i>N</i> -octadecyl diethanolamine	0.90

Preparation: adding Glycerol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, and stir resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity and the shear rate at -20°C, 0°C, and 20°C. As shown in FIG. 3, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. Moreover, the zero-shear viscosity of the deicing/anti-icing fluid significantly increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 8

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	43.80
Alcohol: Glycerol	55.32
Surfactant: <i>N</i> -octadecyl diethanolamine	0.88

Preparation: adding Glycerol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity and the shear rate at -20°C, 0°C, and 20°C. As shown in FIG. 4, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. Moreover, the zero-shear viscosity of the deicing/anti-icing fluid significantly increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 9

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
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Deionized water	43.90
Alcohol: Glycerol	55.44
Surfactant: <i>N</i> -octadecyl diethanolamine	0.66

Preparation: adding Glycerol to deionized water at room temperature according to the amount in the formula, add *N*-octadecyl diethanolamine, stir the resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity and the shear rate at -20°C, 0°C, and 20°C. As shown in FIG. 5, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. Moreover, the zero-shear viscosity of the deicing/anti-icing fluid significantly increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 10

In this example, a deicing/anti-icing fluid is prepared according to the following formula:

Component	Parts by mass (100 parts in total)
Deionized water	43.61
Alcohol: Glycerol	55.08
Surfactant: <i>N</i> -octadecyl diethanolamine	1.31

Preparation: adding Glycerol to deionized water at room temperature according to

the amount in the formula, add *N*-octadecyl diethanolamine, stir resulting mixture until the *N*-octadecyl diethanolamine is completely dissolved to obtain a deicing/anti-icing fluid.

A rotational rheometer (Anton Paar, MCR 302) is used to determine the relationship between the apparent viscosity and the shear rate at -20°C, 0°C, and 20°C. As shown in FIG. 6, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly. Thus, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid. Moreover, the zero-shear viscosity of the deicing/anti-icing fluid significantly increases as the temperature decreases, and the viscosity is greater at a low temperature, making the deicing/anti-icing fluid suitable for low-temperature environments.

Example 11

In this example, the components of the deicing/anti-icing fluid, the content of each component, and the preparation method are the same as those in Example 2.

The relationship between the apparent viscosity of the deicing/anti-icing fluid and the shear rate is determined at -20°C, 0°C, and 20°C. As shown in FIG. 7, at the investigated temperatures, the fluid exhibits a stable shear platform and has a higher apparent viscosity under a low shear rate, and as the shear rate increases, the viscosity decreases significantly, that is, the fluid shows an obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid.

Example 12

In this example, the components of the deicing/anti-icing fluid, the content of each component, and the preparation method are the same as those in Example 3.

The relationship between the apparent viscosity of the deicing/anti-icing fluid and the shear rate is determined at -20°C, 0°C, and 20°C. As shown in FIG. 8, the fluid exhibits a higher apparent viscosity under a low shear rate, and as the shear rate increases, the apparent viscosity decreases significantly. Thus, the fluid shows an

obvious shear-thinning behavior, which is consistent with the rheological behavior of a non-Newtonian deicing/anti-icing fluid.

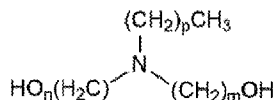
Example 13

In this example, the components of the deicing/anti-icing fluid, the content of each component, and the preparation method are the same as those in Example 6.

The bottom halves of an aluminum substrate, a glass substrate and a plastic substrate are immersed in the deicing/anti-icing fluid separately, and the deicing/anti-icing fluid easily adhere to the surfaces of these substrates. The substrates are then placed in an environment with a temperature of -20°C and a relative humidity of 40%. 5h later, the surfaces of the substrates adhered with no deicing/anti-icing fluid are almost completely frozen, while the surfaces adhered with the deicing/anti-icing fluid are nearly unchanged (FIG. 9). It can be seen from above that the deicing/anti-icing fluid has excellent anti-icing performance.

WHAT IS CLAIMED IS:

1. An aircraft deicing/anti-icing fluid thickened by an alkyl alkanolamine surfactant, comprising, in mass percentage, 27% to 66% of alcohol, 32% to 72% of deionized water, and 0.4% to 2.0% of surfactant, wherein the surfactant is at least one of alkyl alkanolamine surfactants with a structure having the following general formula,



wherein, n is 1 to 5; m is 1 to 5; p is 15 to 21; and n, m and p are all integers.

2. The aircraft deicing/anti-icing fluid of claim 1, wherein the alkyl alkanolamine surfactant is *N*-octadecyl diethanolamine.

3. The aircraft deicing/anti-icing fluid of claim 1 or claim 2, wherein the alcohol is at least one of alkyl diol with 2 to 5 carbon atoms and alkyl polyol with 2 to 5 carbon atoms.

4. The aircraft deicing/anti-icing fluid of claim 3, wherein the alkyl diol is ethylene glycol, 1, 2-propylene glycol or 1,3-propylene glycol; and the alkyl polyol is glycerol.

5. A method for preparing the aircraft deicing/anti-icing fluid as defined in any one of claims 1-4, comprising: mixing the deionized water and the alcohol, stirring the mix deionized water and alcohol to obtain a mixed solvent; adding the alkyl

alkanolamine surfactant to the mixed solvent to obtain a resulting mixture, and stirring the resulting mixture until the alkyl alkanolamine surfactant is completely dissolved, wherein the alkyl alkanolamine surfactant is as defined in claim 1 or claim 2.

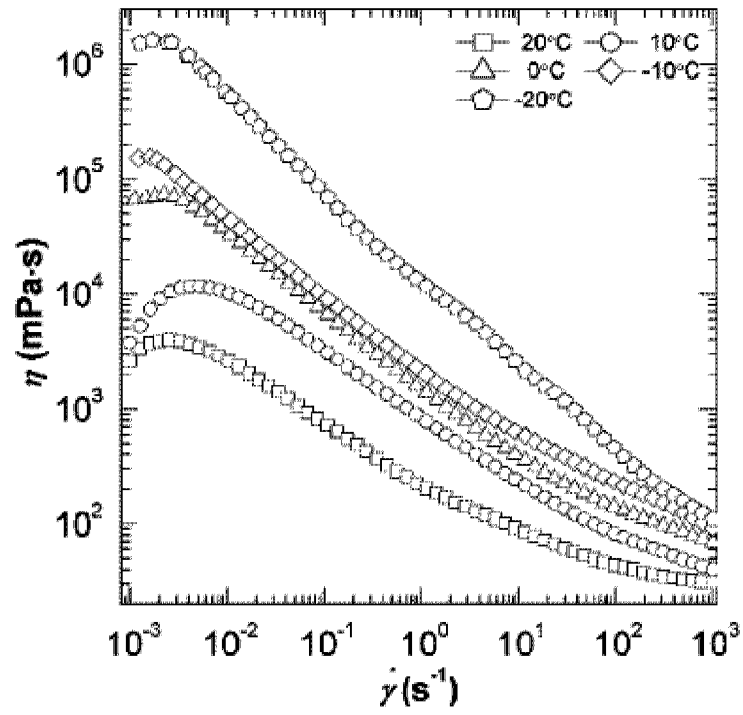


FIG. 1

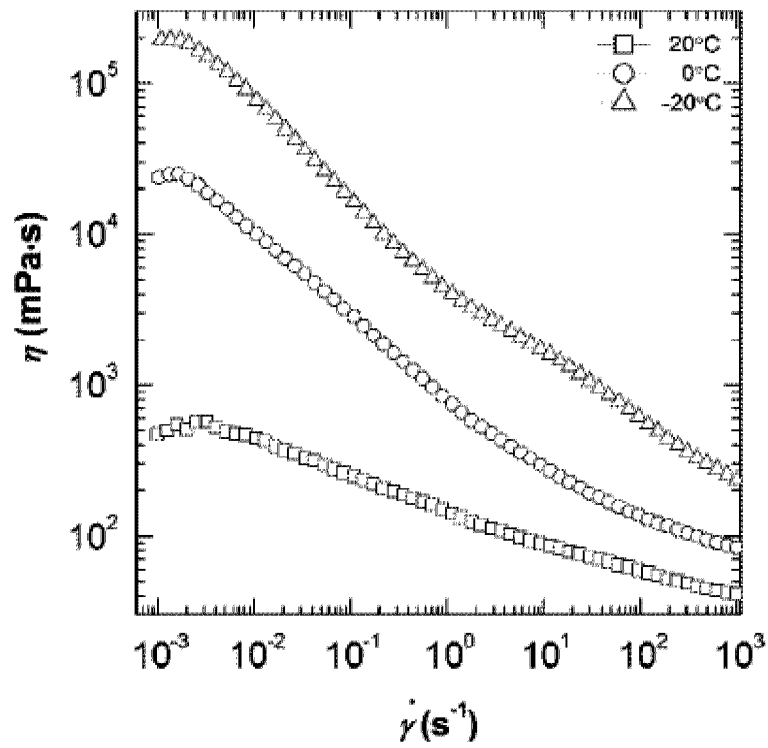


FIG. 2

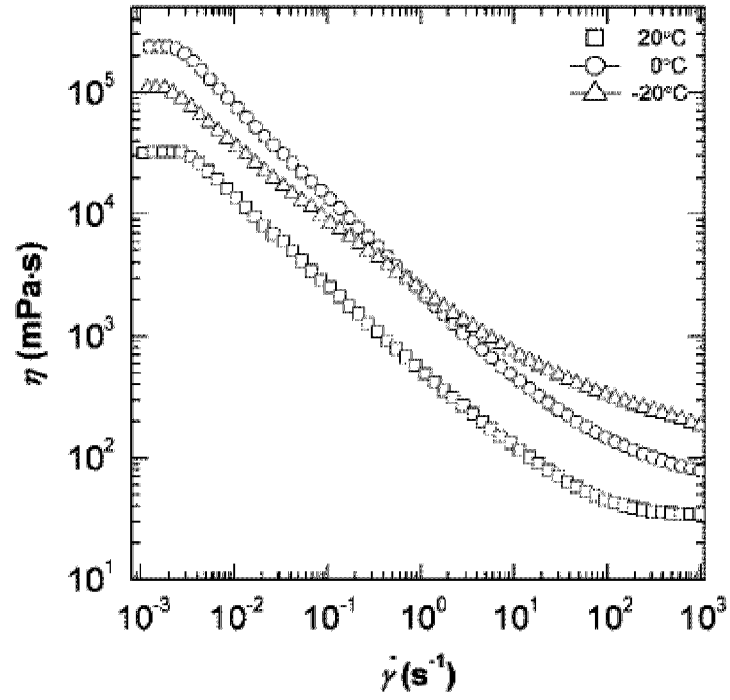


FIG. 3

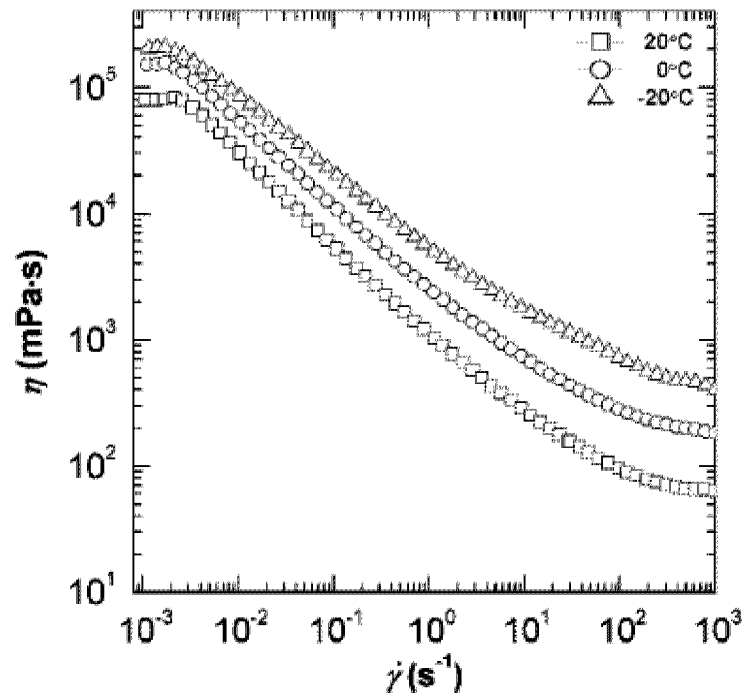


FIG. 4

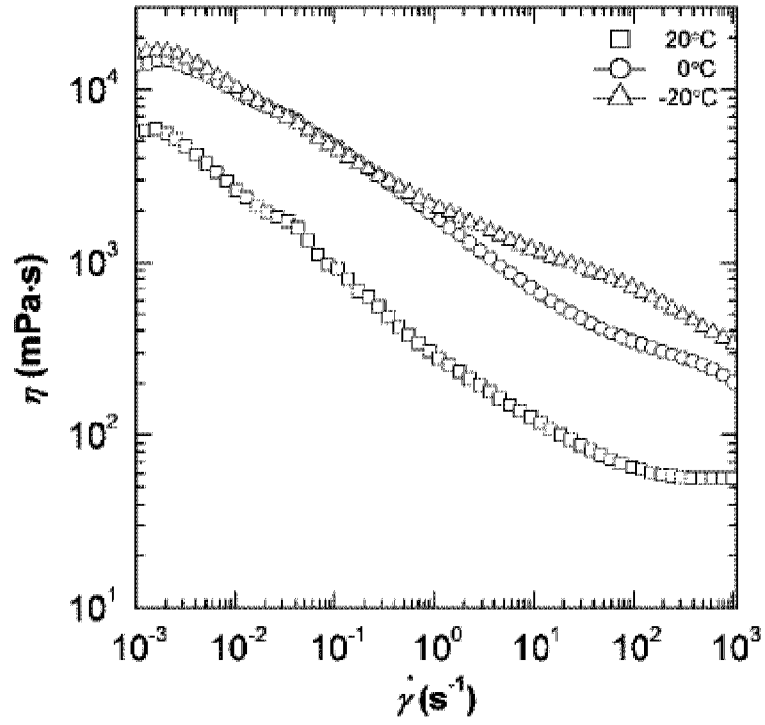


FIG. 5

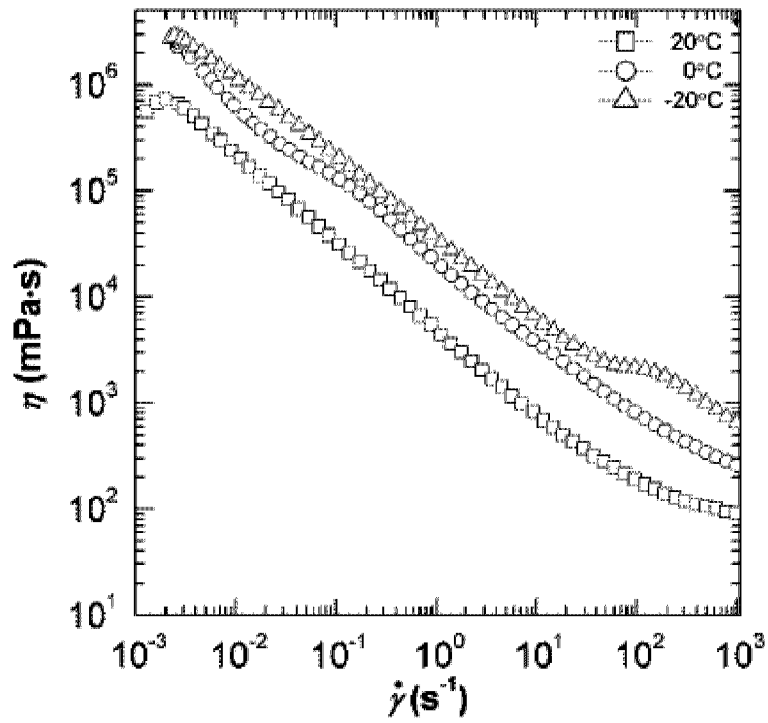


FIG. 6

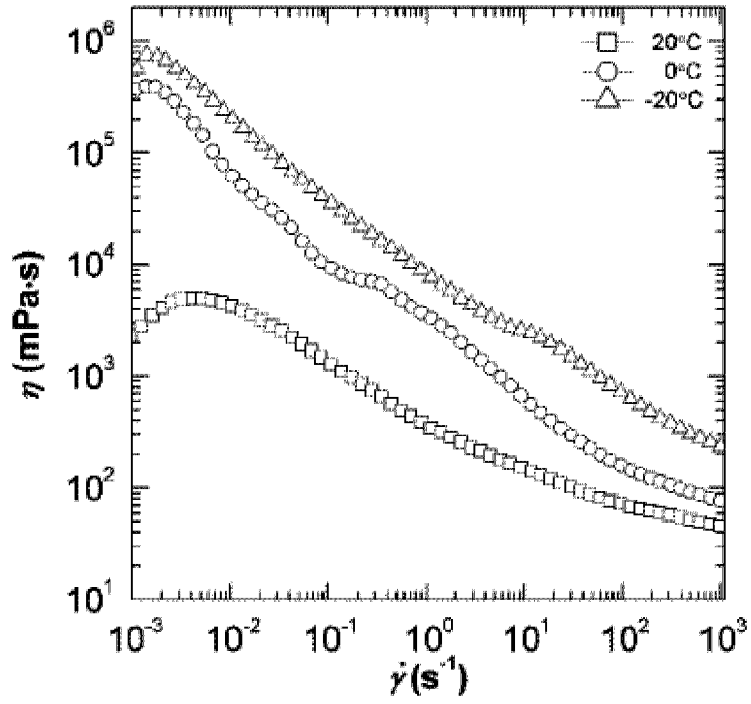


FIG. 7

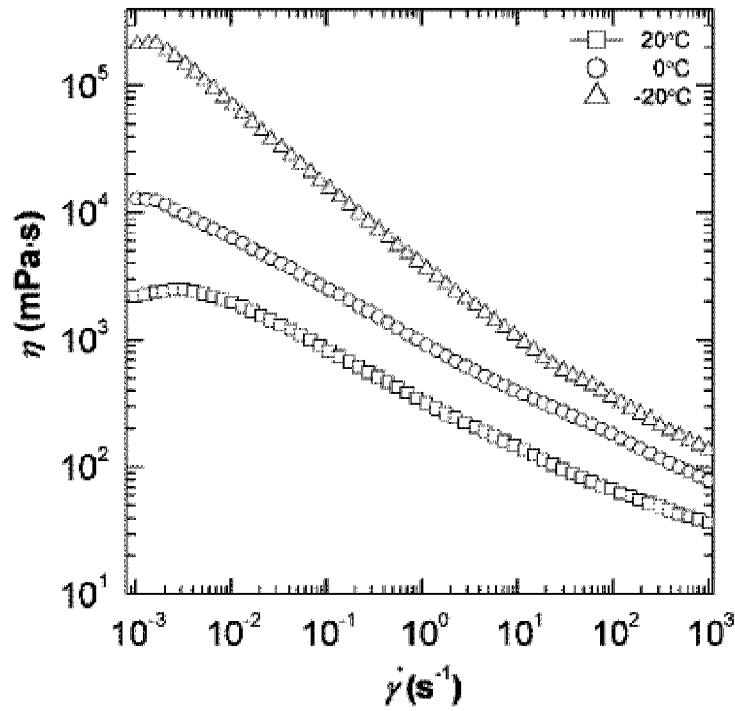
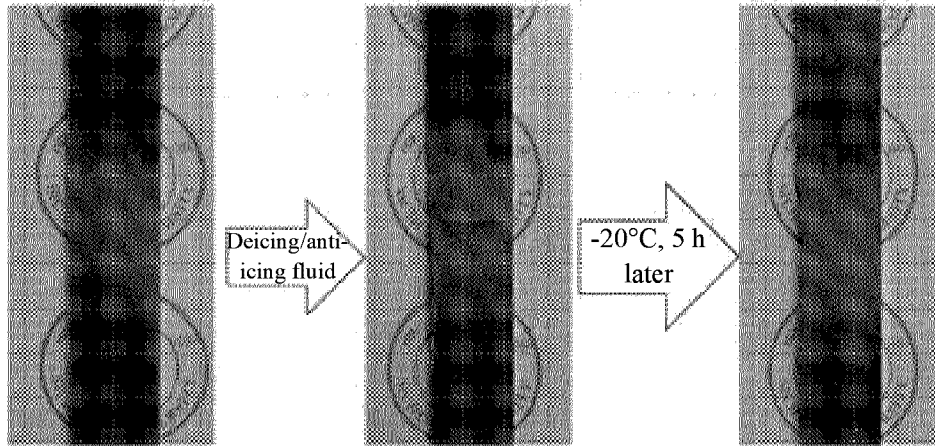
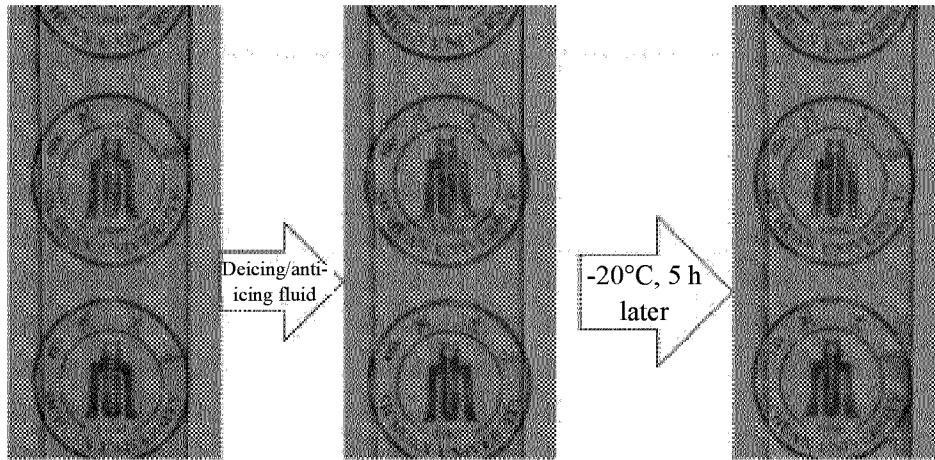


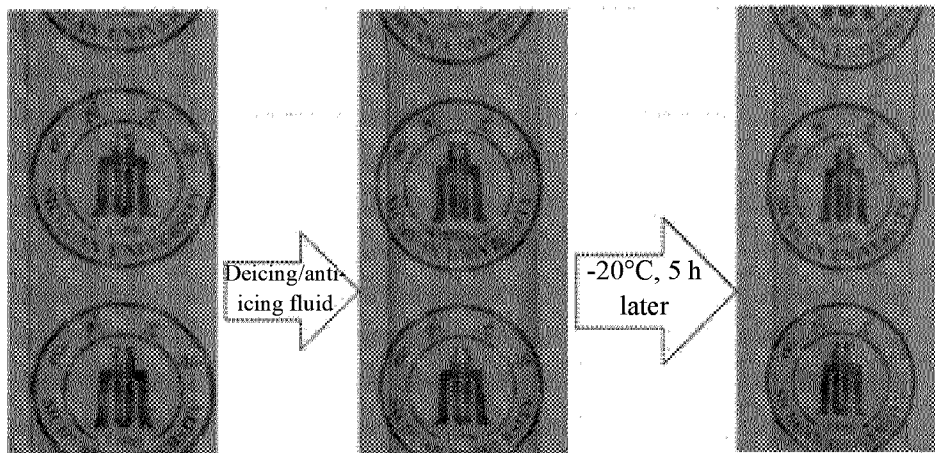
FIG. 8



(a)



(b)



(c)

FIG. 9

