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Wetting Hysteresis Test of Solids by Different Types of Surfactants

Lead

OMÓWIENIE

The results of the studies of the wetting hysteresis of solids by surfactant solutions were presented. Using the K100MK2 tensiometer surface tension isotherms of tested surfactants were specified. On their basis the critical micelle concentration (CMC) of each surfactant was determined. Wetting properties were tested at concentrations of 0.5 CMC, 1 CMC, 2 CMC. The following five solid materials were used for the measurements: polyethylene, poly(methyl methacrylate), polytetrafluoroethylene, copper and glass. Differences among the wetting properties of surfactants on tested solid materials were discussed and the results were compared with the literature data.

Keywords: wetting, hysteresis, surface tension, contact angle.

Introduction

"A class" fires of solid materials predominate in fire brigade extinguishing operations. The primary extinguishing agent in such cases is water. The most important properties which determine the extinguishing effectiveness are spilling and wetting ability. The former is related to the surface tension and the latter to the interaction of water molecules and the solid surface. Both of these parameters are linked to each other and characterized by the surface tension of the so called contact angle.

The shape of a liquid droplet on a solid surface, in the area of 3 phases coming into contact, depends on the liquid surface tension, solid – vapor interfacial tension, solid – liquid interfacial tension, solid – liquid interfacial tension and the contact angle. The relationship of the forces of the respective interfacial tensions at the three phases point can be described by the Young equation [1] (1):
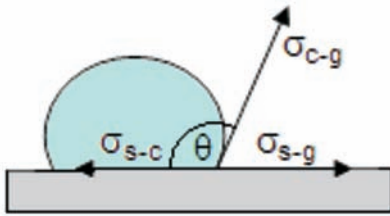
Fig. 1. Illustration of contact angles formed by a sessile drop
Source: own work based and [15].

$$cos\theta = \frac{\sigma_{s-g} - \sigma_{s-c}}{\sigma_{c-g}} \qquad (1)$$

Where:
  – contact angle,
  s-v – solid – vapour interfacial tension,
  s-l – solid – liquid interfacial tension,
  l-v – solid – vapour interfacial tension,
Liquid – vapour interfacial tension is usually referred to as surface tension .

The measure of the wettability is the contact angle   and the value of the cosine. Perfect wetting occurs when the contact angle   is 0° (cos   = 1) and there is a complete absence of wetting, when   = 180° (cos   = -1).

Another measure of wettability is a proper adhesion defined as work needed to tear a liquid off from a unit solid surface, creating simultaneously two new interfacial surfaces: liquid – gas surface and solid – vapour surface. The value of this work can be derived from the equilibrium of surface free energy [1]:

$$W_{adh} = \sigma_{c-g} + \sigma_{s-g} - \sigma_{s-c} \qquad (2)$$

After considering equations (1):

$$W_{adh} = \sigma(1 + \cos\theta) \qquad (3)$$

Proper cohesion is a measure of cohesion forces occurring in a liquid. It is defined as work needed to break a liquid column with a unit section, creating two free surfaces of the same size:

$$W_{koh} = 2\sigma \qquad (4)$$

In the case of perfect wetting (= 0°, cos   = 1) adhesion force of cohesion forces is equal to:

$$W_{adh} = 2\sigma = W_{koh} \qquad (5)$$

For contact angles 0 <   < 180° adhesion force is smaller than the cohesive forces. These are cases of limited wetting. The contact angle range is divided into two ranges: 0 <   < 90° and 90 <   < 180°. This is determined by the value of the capillary pressure that is positive for the first range, which means that the liquid can be absorbed into the capillary structure of the solid. Capillary pressure can be described by the formula [2]:

$$p_k = \frac{2\sigma \cos\theta}{r} \tag{6}$$

Where: **r** – the radius of the capillary.

The contact angle in the $0 < \theta < 90°$ range signifies good wettability. Cosine of the angle has a positive value, so the capillary pressure is also positive. The liquid is drawn into the capillary. For the values of contact angles in the range of $90 < \theta < 180°$, the cosine of the angle is negative, capillary pressure is also negative, and the liquid is not absorbed into the capillaries. The measurement of the contact angle by analyzing the shape of the liquid droplet applied to the surface gives a value called a static contact angle. This is not the value that can be considered as a constant, reproducible parameter characteristic of the material. To obtain such a condition (repetitious measurement) a test surface would have to be perfectly smooth, chemically homogenous and clear. Most of the material is not homogeneous; the degree of smoothness is difficult to define. It is relatively easy to obtain adequate sample purity but it is also a frequent cause of the lack of measurement results repeatability. Other causes of the contact angle changes are as follows:

- the evaporation of the liquid,
- migration of surfactants from the solid surface to the liquid surface,
- chemical reaction between the solid and liquid,
- substances dissolved in the drop migrating to the surface,
- the solid being dissolved or swollen by the liquid,
- solid interaction with a surface (creating hydrogen bonds, chemical reaction),
- migration of a substance dissolved in liquid to an interfacial boundary,
- partial dissolving of solid surface components in a liquid.

The measurements of dynamic contact angles describes the process at the liquid/solid boundary during an increase in the volume (Advancing Contact Angle) or a decrease in the volume (Receding Contact Angle) of the drop, during the wetting and de-wetting processes. The advancing contact angle is greater than the receding contact angle. The difference stems from the fact that the rear part of the drop dripping from the solid surface does not encounter the same force as in the case of a front portion of incoming droplet surface wetting. The difference of these angles is called wetting hysteresis, which ranges from several to dozens of degrees. The significance of contact angle hysteresis has been extensively investigated and general conclusion is that it arises from surface roughness and/or heterogeneity. The measurement of dynamic contact angle makes it possible to reduce the influence of surface irregularity by averaging the measurement results. Dynamic methods are particularly useful for assessing the ability of wetting surfactants solutions, which depend on the rate of change of the phase boundary of vapour-liquid and liquid-solid.

1. Wetting hysteresis measurements by the Wilhelmy method

The Wilhelmy method is based on the measurement of the force which is needed to overcome the resistance of the liquid when the solid plate with known wetted length is immersed in or withdrawn from the liquid of a known surface tension. The contact angle determined by immersing the plate in a liquid is called an advancing contact angle $_A$ and the angle determined by withdrawing the plate is called a receding contact angle $_R$. Contact angles can be calculated from the formula: [7]:

$$\cos \theta = \frac{F}{L \cdot \sigma} \tag{7}$$

where:
– contact angle,
F – Wilhelmy wetting force,
– surface tension of the liquid,
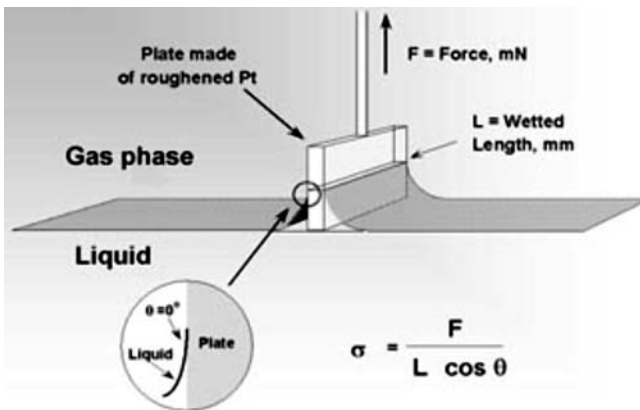L – wetted length.

The measuring principle is shown in Figure 2.

Fig. 2. Wilhelmy plate method of dynamic contact angle measurement.
Source: [8].

2. Characteristics of solids and surfactants

The aim of the research was to compare the wetting ability of different types of surfactants compared to the solid surface of different nature. To compare the wetting ability the measurement of wetting hysteresis was used.

In the study, 5 samples of solids were used, namely: 2 samples of a hydrophilic character (glass, copper) and two of hydrophobic character: polytetrefluoro-ethylene – Teflon (PTFE), polyethylene (PE) as well as one of an indirect

character – polymethyl methacrylate (PMMA). The tested solids weren't the reference materials, with strictly defined composition and properties. To determine the contact angle rectangular plates made from tested solid materials were prepared. The plates were thoroughly degreased and rinsed with distilled water. The surfaces of the tested materials were smooth (no visible roughness). The size of each plate was measured to an accuracy of 0.1 mm and the wetted length was also calculated. To conduct the measurements the surfactants, which are essential components of foam concentrates, were used. Various types of surfactants were tested – ionic and nonionic ones, including:
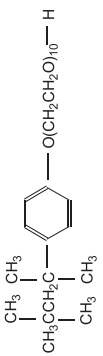
- sodium dodecyl sulfate (SDS) – an anionic surfactant,
- hexadecyltrimethylammonium bromide (CTAB) – a cationic surfactant,
- alkiloamidopropylo betaine (Betaine CAB) – an amphoteric surfactant,
- a polymer of polyethylene glycol ether and p-t-octylphenol (Triton X-100) – a nonionic surfactant.

The table 1 shows characteristics of the tested surfactants.

Critical micelle concentration is defined as the concentration of surfactants above which micelles are spontaneously formed and all additional surfactants added into the system go to micelles. This corresponds to the clear slowdown of the drop of surface tension of the solution with further increase of concentration.

CMC is not a value strictly defined for a specific substance. It is determined graphically on the basis of surface tension isotherm graph. It depends on the temperature of the solution, the ambient temperature, the degree of purity of the tested substance and the water and also on the method of measuring the surface tension and the individual characteristics of the measuring position. In the studies, to determine the contact angles, K100MK2 tensiometer of the Krüss Company was used. The same tensiometer was used to measure the surface tension of the tested surfactants (the Wilhelmy plate method). The solutions were prepared by a gravimetric method in demineralized water with 0.06 mS/m conductivity. The initial concentrations of the surfactants were higher than the CMC values reported in the literature. After the measurement of the surface tension further solutions were prepared by two dilutions. The surfactant solutions used in these studies were lucid. Measurements were carried out to obtain a surface tension of 50 to 60 mN/m. The temperature of th solutions was $25 \pm 1°$ C and the ambient temperature was $23 \div 26°$. After the measurements the surface tension isotherm was made and on the basis of the isotherm graph CMC the value was determined by the graphical method (Figure 3).

Table 1. *The characteristics of the tested surfactants*

Name	SDS	CTAB	BETAINE CAB	TRITON X-100
Type	**Anionic**	**Cationic**	**Amphoteric**	**Nonionic**
Molecular formula	$C_{12}H_{25}SO_4Na$	$C_{19}H_{42}NBr$	$RC_8H_{15}N_2O_2$, R– radicals of coconut oil fatty acids	$C_{34}H_{62}O_{11}$
Structural formula	$C_{12}H_{25}O-S(=O)(=O)-O^{-} Na^{+}$	$CH_3(CH_2)_{14}CH_2-N^{+}(CH_3)(CH_3)-CH_3\; Br^{-}$	$R-C(=O)-N(H)-CH_2CH_2CH_2-N^{+}(CH_3)(CH_3)-CH_2COO^{-}$	$CH_3C(CH_3)(CH_3)CH_2C(CH_3)(CH_3)-C_6H_4-O(CH_2CH_2O)_{10}-H$
Molar mass [g/mol]	288.4	364.5	342.5 (dla $R-C_{11}H_{23}$)	625
Density g/cm^3	1.05 [9]	1.01 [6]	1.04 [7]	1.07 [10]
CMC mmol/dm^3	8.1 ÷ 11.5 [14, 17]	0.9 ÷ 1 [11, 14]	0.9 [4]	0.22 ÷ 0.24 [12]
appearance	white powder	white powder	transparent, light yellow liquid	transparent, colorless liquid
producer	CARL ROTH GmbH & Co.	ACROS ORGANICS	Zakłady Azotowe Kędzierzyn	CARL ROTH GmbH & Co.
purity	> 99 %	> 99 %	water concentrate ~30 % by weight	pure

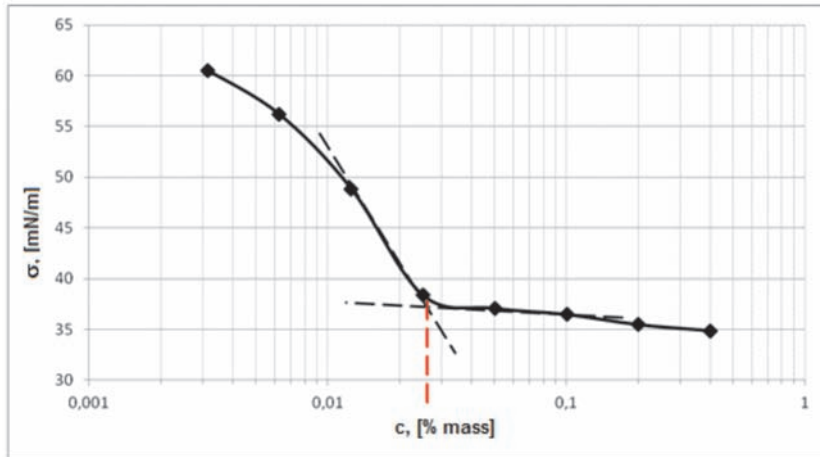Source: own work based and [4, 6, 7, 9, 10, 11, 12, 14, 17].

Fig. 3. Surface tension isotherm of CTAB

Source: own work.

The following values of CMC were obtained: SDS – 4.1 mmol/dm^3, CTAB – 0.8 mmol/dm^3, Betaine CAB – 0.25 mmol/dm^3 and Triton X-100 – 0.30 mmol/dm^3. In the case of Triton X-100, the obtained CMC value is close to the CMC reported in the literature. Usually 0.22 to 0.24 mmol/dm^3 range of CMC concentration is given. In the study [16] TRITON CMC was determined as 0.31 mmol/dm^3 with the use of the ring method, so almost identical to the value obtained in the present study. CTAB CMC is also close to the literature, considering the error of the graphical method of determining CMC. In other studies the surface tension of CTAB measured by the bubble and stalagmometric methods was similar and stood at approximately 1.0 mmol/dm^3. For SDS, the determined CMC value is two times lower and for BETAINE – more than three times lower. However, the literature contains surface tension values much lower than the most frequently cited. Thus, it is believed that the surface tension of SDS values is in the range 8.1 ÷ 11.5 mmol/dm^3 [14, 17]. But, in the study [13], the surface tension of SDS (high purity) determined by the Wilhelmy method was 5.6 mmol/dm^3 and in the study [5] – even 2.4 mmol/dm^3.

3. The study of wetting hysteresis

The objective of the study was to determine the effect of different types of surfactants characterized by an advancing and a receding contact angle on the wetting ability of water value. The wetting hysteresis of material samples by surfactant solutions were tested by the previously described Wilhelmy method, with the use of K100MK2 Krüss tensiometer. In the studies the solutions of surfactants in demineralized water at concentrations of 0.5 CMC, 1 CMC and 2 CMC were used. For each study 100 cm^3 of solution was prepared, about 70 cm^3

of which was placed in the measuring vessel. Before each measurement, a test sample (plate) of the solid material was rinsed with tap water, followed by distilled water, washed with ethanol, then treated with acetone and finally allowed to dry. The plate was secured to a special holder in the tensiometer weight system. Before the measurement, the output data: such as the name of the sample and its circumference, the name of the surfactant and the surface tension of the solution (which, for the concentration of 0.5 CMC, 1 CMC, and 2 CMC were read off from the previously prepared surface tension isotherms) were entered in a computer programme supporting the measurement. The measurement of wetting hysteresis was started, which from that moment was proceeding fully automatically. The results were a wetting hysteresis graph and the average values of advancing and receding contact angle and the standard deviation for the measurement of contact angles. The standard deviation for all measurements is divided in the range of 2.3 – 3.8. The figures 4 and 5 show examples of wetting hysteresis graphs of PTFE and copper by water and surfactant solutions.
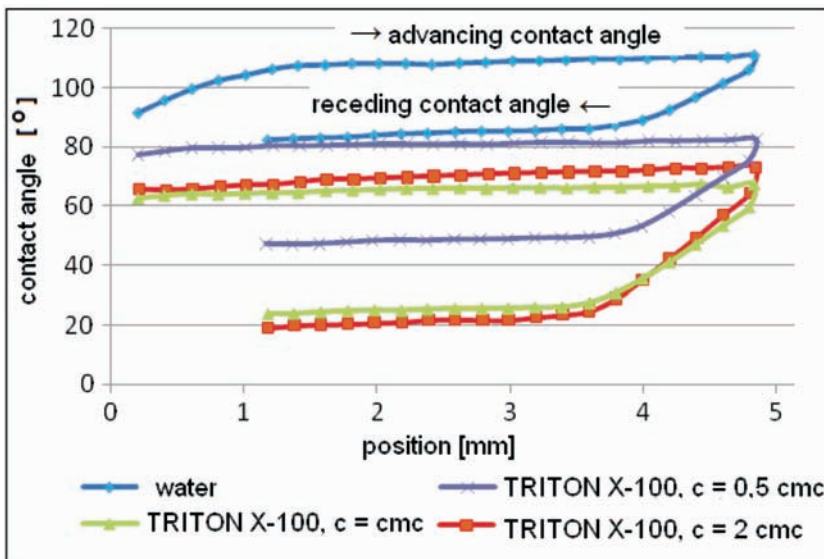

Fig. 4. Wetting hysteresis of PTFE and copper by water and aqueous solutions of Triton X-100
Source: own work.

The wetting hysteresis of Teflon by TRITON solutions is greater than the wetting hysteresis of PTFE by water. This difference between wetting hysteresis water and TRITON solutions is twice the concentrations equal 1 CMC and 2 CMC. For all concentrations of TRITON solutions advancing contact angles are lower than the receding contact angle of water.
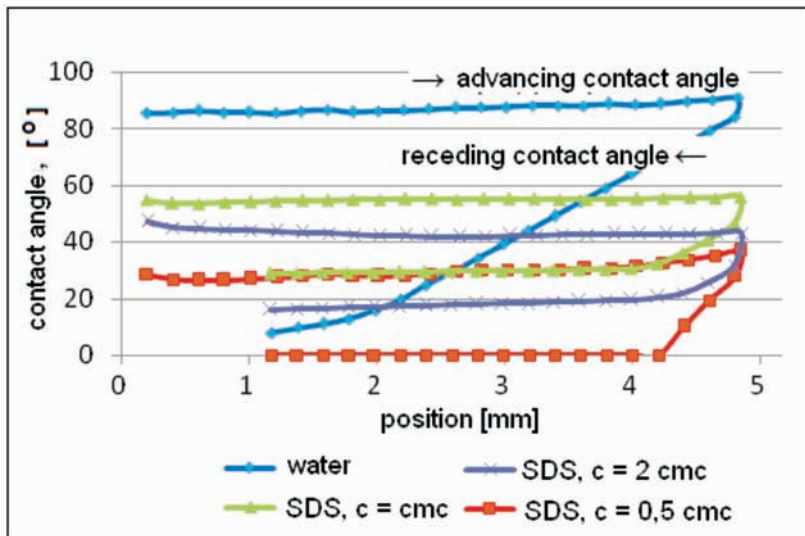
Fig. 5. Wetting hysteresis of copper by water and aqueous solutions of SDS
Source: own work.

The wetting hysteresis of copper by water is more than 40°. Each of the solutions of SDS caused A reduction of the wetting hysteresis of copper was caused by each of the SDS solutions. The lowest wetting hysteresis occurs at 0.5 CMC concentration and the highest wetting hysteresis occurs at a concentration of 1 CMC.

All tests of wetting hysteresis were carried out in ambient temperature of 25 ±1°C. The solutions also had the same temperature. The results of measurement are shown in the table 2.

The studies have confirmed the anticipated nature of solid samples. Glass and copper have the hydrophilic character (contact angles of less than 90°). Glass is usually considered to be perfectly wettable material so it was expected to have much lower values of contact angles of wetting by water. The received value of 51.2° of the advancing contact angle is relatively high. a receding contact angle (31.4°) is far from perfect wettability.

Teflon and polyethylene have clearly hydrophobic nature as expected. The values of the advancing contact angle of water 105.9° (Teflon) and 107.9° (polyethylene) are close to the data in the specialist literature [14, 15].

If we take the advancing contact angle as a measure of wetting ability, the addition of all tested surfactants caused the reduction of the contact angle, thus improving the wetting ability, with one exception. For CTAB solutions, higher values of contact angles, both advancing and receding ones, were obtained. Also, compared to other materials, CTAB showed a weak wetting ability, which correlates with the results of the previous studies concerning the capillary saturation [9].

Table 2. Advancing (θ_A) and receding (θ_R) contact angles and wetting hysteresis (H) of solid samples by surfactants solutions

Solid	Water θ_A [°]	Water θ_R [°]	Water H [°]	Water H [%]	c [x CMC]	SDS θ_A [°]	SDS θ_R [°]	SDS H [°]	SDS H [%]	CTAB θ_A [°]	CTAB θ_R [°]	CTAB H [°]	CTAB H [%]	Betaina CAB θ_A [°]	Betaina CAB θ_R [°]	Betaina CAB H [°]	Betaina CAB H [%]	Triton X-100 θ_A [°]	Triton X-100 θ_R [°]	Triton X-100 H [°]	Triton X-100 H [%]
Glass	51.2	31.4	19.8	38.7	2	1.6	0.0	1.6	100.0	51.6	35.8	15.8	30.6	48.3	39.6	8.7	18.0	34.5	16.4	18.1	52.5
Glass					1	9.6	0.0	9.6	100.0	56.6	32.6	24.0	42.4	50.7	45.2	5.5	10.8	34.4	7.4	27.0	78.5
Glass					0.5	37.3	18.6	18.7	50.1	55.3	46.4	8.9	16.1	60.4	45.4	15.0	24.8	35.0	2.1	32.9	94.0
Copper	84.9	47.7	37.2	43.8	2	34.8	2.0	32.8	94.3	64.3	28.1	36.2	56.3	57.6	36.6	21.0	36.5	59.7	16.1	43.6	73.0
Copper					1	38.3	1.4	36.9	96.3	64.0	23.8	40.2	62.8	61.9	38.8	23.1	37.3	63.0	13.2	49.8	79.0
Copper					0.5	43.1	19.2	23.9	55.5	69.9	39.4	30.5	43.6	71.1	48.3	22.8	32.1	70.0	15.4	54.6	78.0
PTFE	105.9	86.5	19.4	18.3	2	80.1	48.6	31.5	39.3	73.3	45.7	27.6	37.7	76.1	42.9	33.2	43.6	67.1	19.7	47.4	70.6
PTFE					1	74.7	23.6	51.1	68.4	77.3	42.4	34.9	45.1	78.6	53.7	24.9	31.7	69.9	27.4	42.5	60.8
PTFE					0.5	85.5	25.5	60.0	70.2	80.8	48.7	32.1	39.7	86.4	64.0	22.4	25.9	80.3	41.7	38.6	48.1
PE	107.9	67.9	40.0	37.1	2	35.4	0.8	34.6	97.7	68.9	13.9	55.0	79.8	75.4	32.1	43.3	57.4	14.1	0.0	14.1	100.0
PE					1	38.9	1.1	37.8	97.2	63.0	13.8	49.2	78.1	79.4	40.9	38.5	48.5	18.0	0.5	17.5	97.2
PE					0.5	38.8	2.0	36.8	94.8	63.5	27.0	36.5	57.5	78.6	43.4	35.2	44.8	42.8	0.5	42.3	98.8
PMME	89.5	47.5	51.0	57.0	2	0.0	0.0	0.0	100.0	43.4	16.4	27.0	62.2	59.7	26.7	33.0	55.3	40.9	4.0	36.9	90.2
PMME					1	0.0	0.0	0.0	100.0	54.5	24.2	30.3	55.6	62.4	34.6	27.8	44.6	41.9	3.8	38.1	90.9
PMME					0.5	0.0	0.0	0.0	100.0	55.5	39.1	16.4	29.5	60.9	38.2	22.7	37.3	61.0	6.6	54.4	89.2

Source: own work.

The comparison of the wetting abilities of the surfactant solutions at equal 1 CMC concentrations was presented in the figure 6.
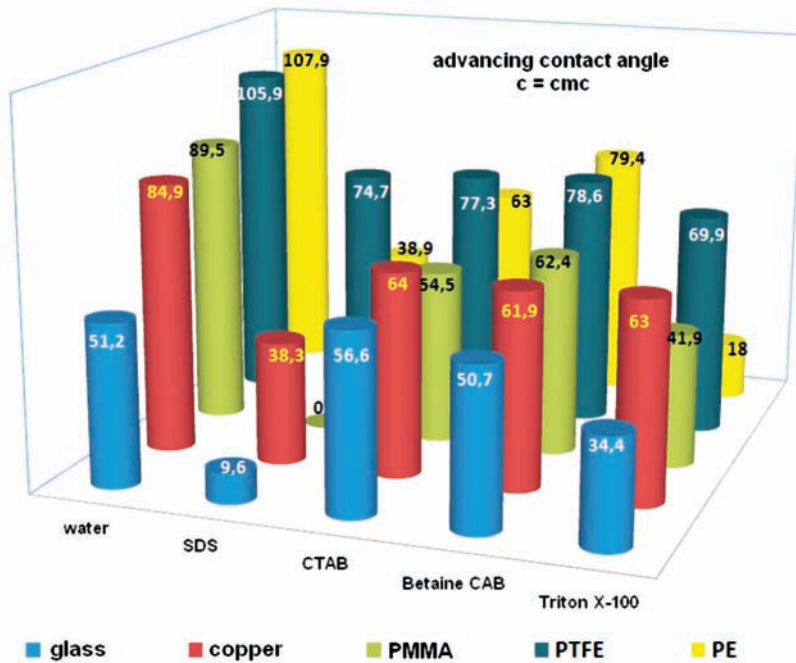

Fig. 6. Advancing contact angles of material samples by surfactant solutions with equal CMC concentration

Source: own work.

Among the studied surfactants cationic surfactant CTAB and ampholytic surfactant – Betaine CAB have significantly worse wetting ability compared to all materials. In other surfactants, anionic SDS has better wetting ability than the non-ionic TRITON X-100 in relation to the materials of hydrophilic character – glass, copper and PMME with indirect properties. Only upon wetting copper by solutions of the 0.5 CMC concentration TRITON X-100 showed a lower advancing contact angle than the SDS. The receding contact angles of glass and copper by TRITON solution having a concentration of c = 0.5 CMC were lower than the receding contact angle of SDS solution. Perfect wettability was obtained when wetting PMME by SDS solutions at all concentrations. These were the only cases of zero advancing contact angle values. Except PMME, zero value of receding contact angles was recorded in three cases: the wetting of glass by SDS solutions with concentrations of 2 CMC and 1CMC as well as the wetting of PE by TRITON solution (2 CMC concentration).

TRITON X-100 has better wetting properties than SDS with hydrophobic materials such as PE and PTFE. In case of PTFE it is a difference of about 5° at the concentration equal to 1 CMC and 0.5 CMC. However, the reduction of the advancing contact angle in comparison to water is not large: in the SDS solution at the concentration of 0.5 CMC ~ 20° and ~ 30° at the concentration of 1 CMC. SDS solution at the concentration of 2 CMC had worse wetting ability than the solution at the concentration of 1 CMC (advancing contact angle higher by 5.4°, and receding contact angle higher by over 20°). For polyethylene advancing contact angles of SDS solutions at the concentration of CMC and 2 CMC of polyethylene were higher by about 20° than advancing contact angles of TRITON solutions. Only at the concentration of 0.5 CMC the contact angle of SDS solution was lower than the contact angle of TRITON solution. For all concentrations receding contact angles of TRITON solutions were lower than the contact angles of SDS solution.

The wetting hysteresis value may be the measure of the wetting abilities because the value of the receding contact angle can be influenced by the degree of modification of the surface by surfactant particles adsorbing on it. The table 2 shows the wetting hysteresis in both: the degrees and per cent, in comparison to the advancing contact angle. Figure 7 summarizes the percentage of wetting hysteresis for water and surfactant solutions at the concentrations equal to 1 CMC.
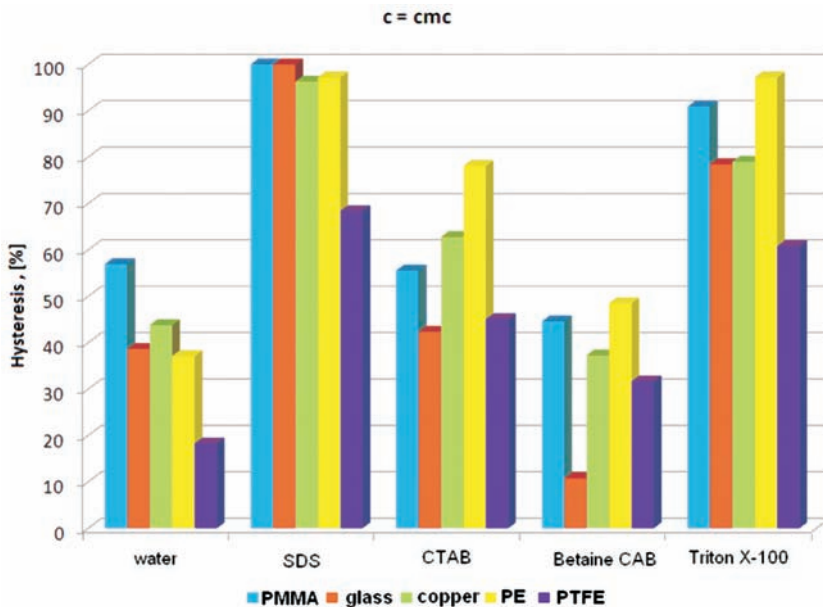

Fig. 7. Wetting hysteresis of tested solid materials by water and surfactant solutions at CMC concentration

Source: own work.

As seen, if we consider the percentage of wetting hysteresis as the criterion of the wetting abilities, SDS appears to be better than TRITON for all materials (including hydrophobic ones). The cationic CTAB, in turn, has better wetting properties than ampholytic BETAINE CAB for all tested samples.

The literature describes many studies of contact angles by surfactant solutions, measured by various methods. In the study [15], contact angle of water on polymethyl methacrylate was about 75°. The contact angle of a SDS solution at a concentration of 8 mmol/dm^3 was 35° and the solution of TRITON X-100 surfactant at the concentration of 0.4 mmol/dm^3 – 30°. In CTAB solutions with the increasing concentration the contact angle decreased until the concentration reached about 1 mmol/dm^3. Then the contact angle was about 34°. The contact angles of solutions with concentrations of 0.5 and 2 mmol/dm^3 were approximately 37° and 33°. The wetting hysteresis was not tested here, however. These angles were tested by a sessile drop technique. In the presented studies the advancing contact angle of water on PMME was about 89.5°, and for CTAB solutions with concentrations equal to 1 CMC and 2 CMC respectively, 54.5 and 43.4°. It is therefore worse wettability than in the cited study [15]. The lower wettability was also observed in the case of TRITON (41.9° a concentration equal to the 1 CMC). Much better wetting ability was obtained for SDS where for all concentrations the wettability was perfect (contact angle of 0°).

In the same study [15] the contact angles on Teflon were reported: for water about 110°, for a CTAB solution at the concentration of 1 mmol/dm^3 – about 78°, and for CTAB solutions at the concentrations of 0.5 and 2 mmol/dm^3 – 79.5° and 78°, respectively. In another paper [3] advancing contact angle of CTAB solutions with the concentration of 0.8 mmol/dm^3 was 83° and the receding contact angle – 62°. In the presented studies the advancing contact angle of CTAB solution with the concentration equal to the 1 CMC on Teflon was 77.3° However, with increasing concentrations (c = 2 CMC) the advancing contact angle decreased to the value of 73.3°. With a significant increase in the concentration of CTAB (10 mmol/dm^3) the contact angle decreased only to about 75° .

In the paper [15] the minimum contact angle of TRITON X-100 solutions on PTFE was achieved at the concentration of about 0.4 mmol/dm^3, and therefore for the value of about 2 CMC (literature value).

The value of the contact angle (67.5°) is almost identical to the value of the advancing contact angle of Teflon obtained in the presented studies – 67.1°. However, in another paper [3] the advancing contact angle at the concentration of 0.3 mmol/dm^3 (c = 1 CMC) was 85° and the receding contact angle was 62°.

In the paper [15] the contact angle of SDS solution having the concentration of 8 mmol/dm^3 on Teflon reached 77°, while in the presented studies the contact angle of the surfactant solution with a concentration equal to 1 CMC (4.1 mmol/dm^3) was about 74.7°, being at the concentration of 2 CMC –80.1°.

4. Conclusions

- Taking the advancing contact angle values as the criterion of wettability, anionic SDS demonstrates the best wetting ability in comparison to the hydrophilic materials (glass and copper) and indirect character materials (PMME); while nonionic TRITON X-100 has the best wetting abilities compared to the hydrophobic materials.
- Taking the percentage of wetting hysteresis as the criterion of wettability, SDS showed the best properties in relation to all samples of solids.
- A cationic CTAB and amphoteric Betaine CAB show clearly weaker wetting properties than SDS and Triton X-100.
- In terms of advancing contact angles CTAB and Betaine CAB show similar properties.
- Taking the percentage of wetting hysteresis as the criterion of wettability, CTAB shows a better wetting ability than BETAINE CAB, in relation to all tested solid materials.
- The scale of surfactants concentrations used in the study turned out to be too narrow. In the further studies to assess the wetting ability in concentrations lower than the concentration of CMC, the concentration not higher than 0.1 CMC has to be taken into account. Whereas for concentrations above the CMC - 10 CMC is needed.

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Badanie histerezy zwilżania materiałów stałych surfaktantami różnych typów

OMÓWIENIE

W artykule przedstawiono wyniki badań histerezy zwilżania materiałów stałych roztworami surfaktantów różnych typów. Za pomocą tensjometru K100MK2 wyznaczono izotermy napięcia powierzchniowego badanych surfaktantów i na podstawie ich przebiegu określono wartości krytycznego stężenia micelizacji (CMC) każdego surfaktantu. Zdolności zwilżające badano przy stężeniach roztworów równych 0,5, 1 i 2 CMC. Do pomiarów wykorzystano 5 materiałów stałych: polietylen, polimetakrylan metylu, teflon, miedź i szkło. Omówiono różnice zdolności zwilżających użytych surfaktantów w stosunku do badanych materiałów stałych i porównano otrzymane wyniki z danymi literaturowymi.

Słowa kluczowe: zwilżanie, histereza, napięcie powierzchniowe, kąt graniczny.