SURFACE TENSION AND DENSITY OF LIQUID SODIUM-POTASSIUM-CESIUM SYSTEM

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ABSTRACT

Experimental data on concentration and temperature dependencies of surface tension and density for Na-K-Cs system are presented. Samples of high purity were used in experiment (99.997 p.c. of basis component). The errors in density and surface tension are of 0.2 % and 0.6 %, accordingly.

Obtained temperature dependencies of ST are expressed in form of linear equations with negative temperature coefficients. The isothermal surface of surface tension of Na-K-Cs system at 375K is constructed.

It has been revealed that surface tension for all studied alloys of the system is constant along X_{Na}:X_{Cs}=14:1 line and is equal to 113 mN/m at 375 K.

Adsorption of component and composition of surface layers of Na-K-Cs system are also calculated. It has been observed that adsorption activity of K is suppressed by adsorption of second component, the Cs. Peculiarities of component adsorption are noted to correlate with behavior of components in corresponding binary systems.

measurements for alloys of alkaline metals. Known gravitational devices by P. Pugachevich were of great importance for ST measurements for fusible liquid metallic alloys, but are useless for alkalines.

2. EXPERIMENTAL PROCEDURE

Double-capillary vacuum pycnometer was used to measure density of liquid metals and alloys with error of 0.2%. Surface tension was measured with error of 1% by mean of well-know method of "big" or "lying drop" with the use of original one-piece soldered device. It allows to measure ST of all alloys along any of radial secants of concentration triangle with only one load of pure components without dehermetisation of the device. That ensures identical preparation and measurement conditions for all samples, what is very important for measurements of surface-sensitive properties and for such active objects as alkali metals and their alloys. Experiment was held in ultra-high vacuum conditions (10^{-8} Pa). Pure components (99.997 % of basis element) were used to prepare alloys. Temperature dependencies of ST and density were studied in the temperature range from 300 to 420-450K. Temperature was determined by differential thermocouples with the precision of 0.5K. Concentration and temperature dependencies of density and ST were measured for 80 different alloys along ten radial secants covering the entire concentration triangle of Na-K-Cs system.

3. RESULTS AND DISCUSSION

Temperature dependencies of density for pure components and all investigated alloys can be described by linear equations with negative coefficient. For example, in the case of the alloy Na +24.6%K +71.8%Cs (weight percents), the one closest to eutectics, the equation has a form

$$\sigma(T) = 84.2 - 0.022\ (T-T_m)$$

where σ is a surface tension, in $mN \cdot m^{-1}$, and T_m is the melting point, in K.

Isotherms of molar volumes for alloys of Na-K-Cs system were calculated from obtained experimental data on density and are shown on fig.1. As one can see, molar volumes of Na-K system change additively with the compound change. Small negative deviations from additivity were observed for K-Cs system. The same kind of deviations were observed for ternary compounds adjoin to binary K-Cs system side of concentration triangle Na-K-Cs. Molar volumes get closer to additive line as sodium substitutes cesium in the alloys and practically coincide with it when concentrations (X_i) of the components are related as $X_{Na} : X_{Cs} = 1 : 1$. Obtained data on concentration dependencies of ST for ternary alloys Na-K-Cs and their side systems Na-K and K-Cs are shown on fig.2. Relative adsorption of potassium and its content in the surface layer of the alloy were calculated from the data and are presented on fig.3-5.

It follows from experimental data and calculations that cesium with the smallest ST among components is a surface-active addition not only for pure sodium and potassium, but also for all of their alloys. Surface-activeness of cesium on sodium is bigger than on potassium and decreases as potassium substitutes sodium in Na-K alloys.

Potassium with ST between ones of Na and Cs, changes the sign of surface activeness. If it is surface-active when $X_{Na} : X_{Cs} > 14 : 1$, it become inactive when $X_{Na} : X_{Cs} < 14 : 1$. This fact is a consequence of presence off a buffer secant, with constant ratio of molar quotas $X_{Na} : X_{Cs} = 14 : 1$. Along this secant the ST of ternary system doesn't depend on content of potassium and is equal to 113 $mN \cdot m^{-1}$ (isoline 3 on fig.2 and 6 on fig.5).

Results of calculations of potassium content in the surface layer of ternary system, assuming it as a monolayer, are presented on fig.4. Even though A.Rusanov's symbatic principle [5] cannot be applied to ternary systems, the model of monomolecular surface layer leads to simbatic change of potassium content in the surface layer as compound changes along radial secants of concentration triangle [6].

4. CONCLUSIONS.

1. Obtained experimental data on molar volumes and surface tension of alloys of Na-K-Cs system show absence of any extremum on isotherms of these properties. They contain no qualitative peculiarities in comparison with isotherms of binary side systems.

2. Radial secant with ratio Na : Cs = 14 : 1 and constant ST, independent from potassium content, was found on ST isotherm of Na-K-Cs system.

3. Adsorption phenomena in studied system are rather involved. It was found that adsorption of one component in the system can suppress adsorption of the over less surface-active component.

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Fig.1 Molar volume isotherms for Na-K-Cs system at 373K:

1 - Cs-K; 2 - Na:Cs=1:11; 3 - 1:2; 4 - 1:1; 5 - 6:1; 6 - Na-K.

Fig.2 Surface tension isotherms for systems at 373 K :

1 - Na-K; 2 - Na:Cs=58:1; 3 - 14:1; 4 - 4:1; 5 - 2:1; 6 - 1:6;

7 - Cs-K.

Fig.3 Isotherms K adsorption at 373K in Na-K-Cs systems :

1 - Na-K; 2 - Na:Cs=58:1; 3 - 14:1; 4 - 6:1; 5 - 2:1; 6 - Cs-K.

Fig.4 Content of K in surface layer in Na-K-Cs systems:

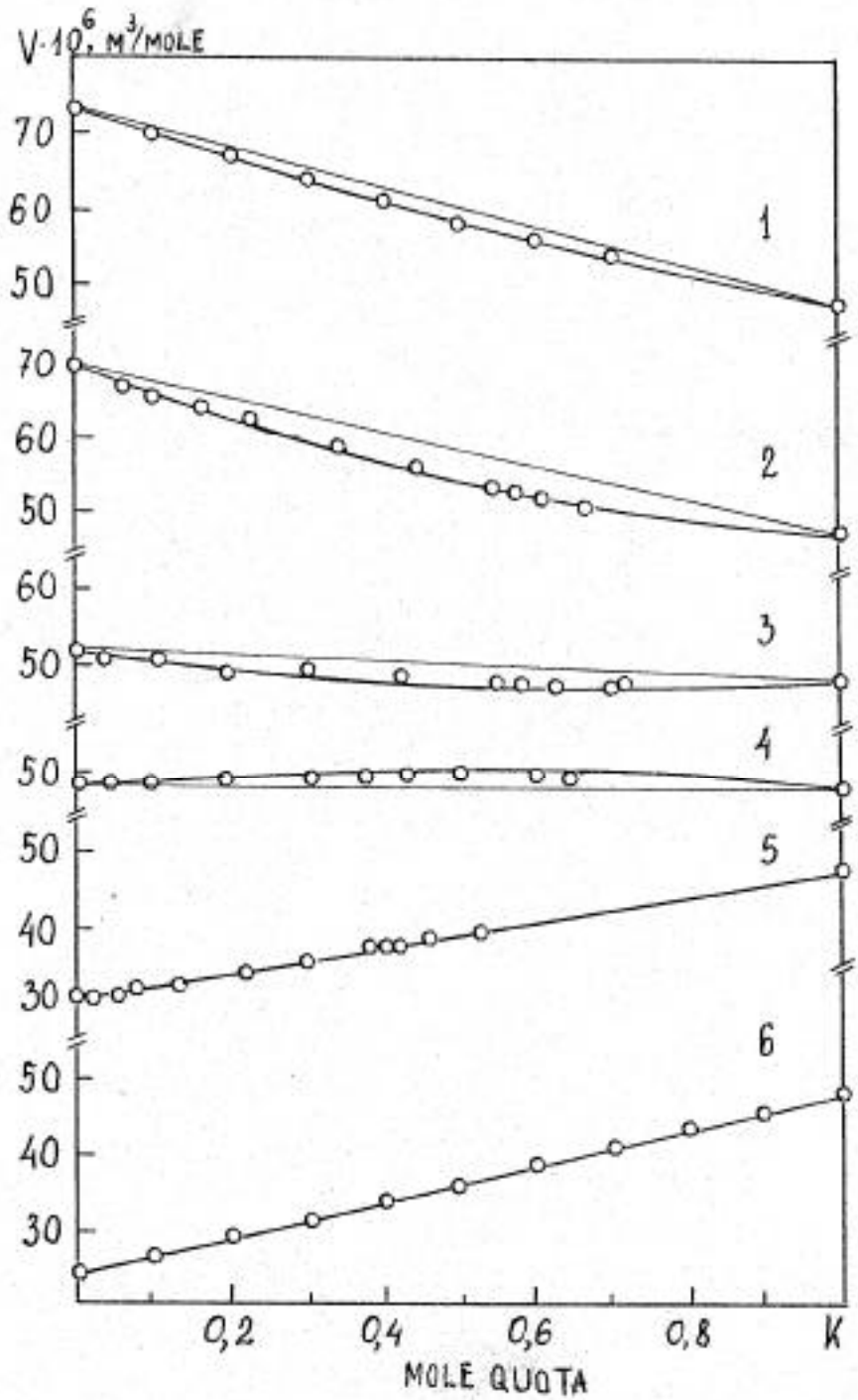
1 - Na-K; 2 - Na:Cs=58:1; 3 - 14:1; 4 - 6:1; 5 - 2:1; 6 - 1:2;

7 - Cs-K.

Fig.5 Isolines of surface tension at 373K for the system Na-K-Cs :

1 - 75 mN/m; 2 - 80; 3 - 90; 4 - 100; 5 - 110; 6 - 113; 7 - 120;

8 - 140; 9 - 160; 10 - 180 mN/m.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K
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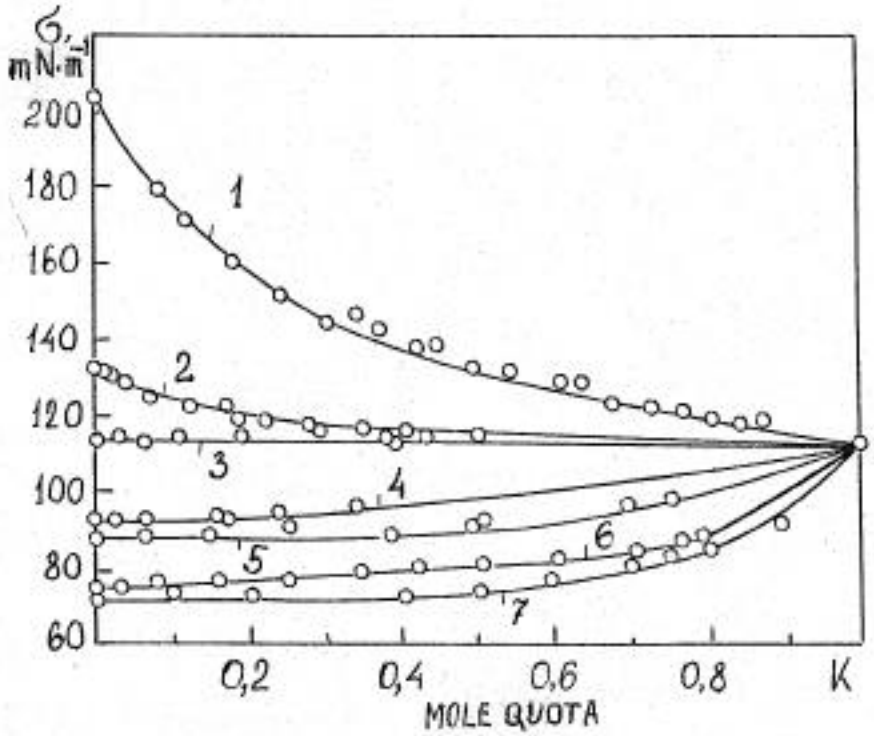
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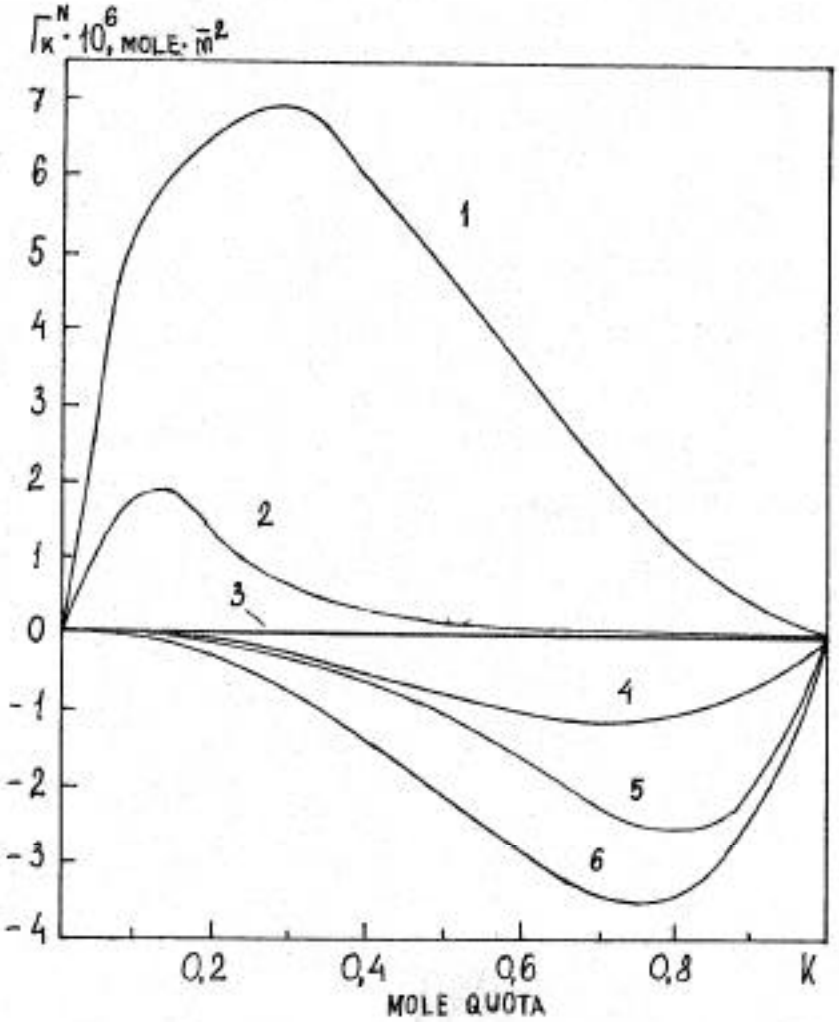
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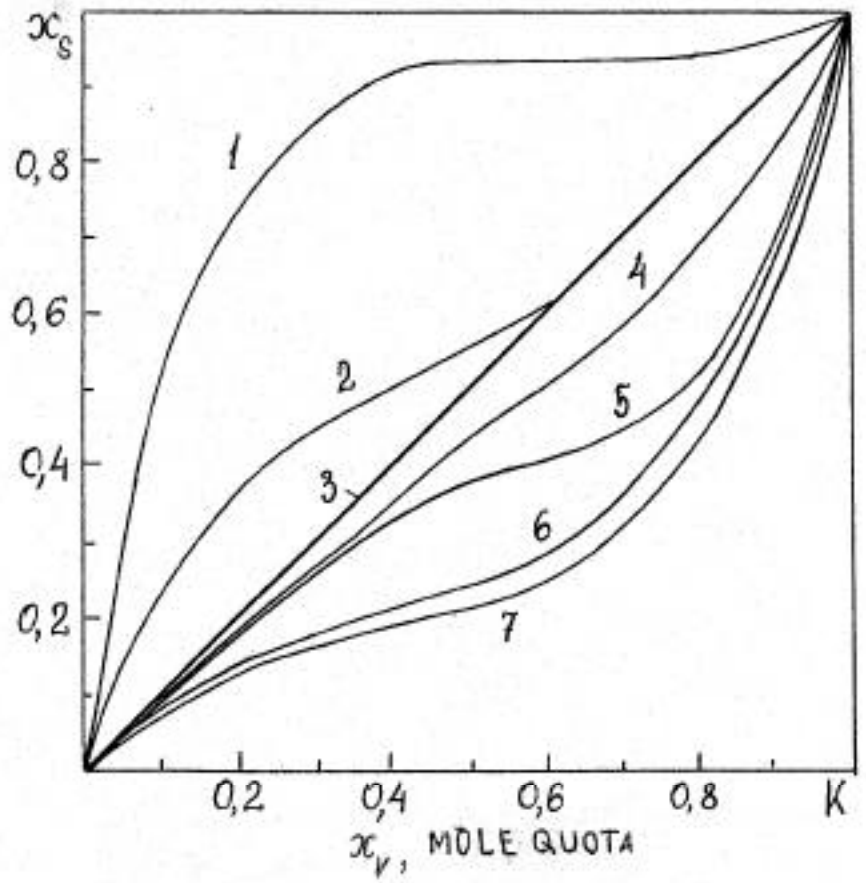
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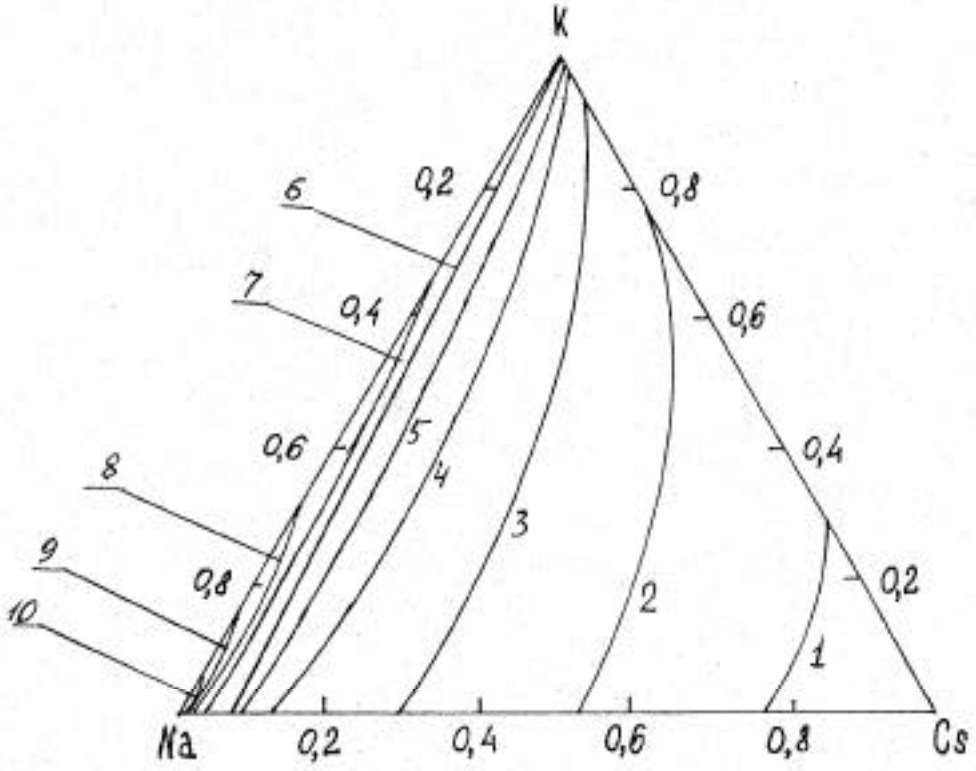
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Cs
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10