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Investigation of Al_2O_3 nanoparticle influence on caloric properties of isopropanol

The aim of this work is the experimental studying the caloric properties of the model nanosystems – isopropyl alcohol with nanoparticles of alumina oxide (Al_2O_3) at different nanoparticle concentrations. Study of thermophysical properties of these model systems is required to assess the of nanoparticle's influence on the phase equilibria parameters and heat caloric properties of working fluids and coolants with nanoparticle additives promising for use in refrigeration systems.

Key words: nanoparticles, isopropanol, specific heat, melting temperature.

Н.А. Шимчук, В.П. Железный

Исследование влияния наночастиц Al_2O_3 на калорические свойства изопропанола

Целью настоящей работы является экспериментальное изучение калорических свойств модели наносистемы – изопропиловый спирт с наночастицами оксида алюминия с различными концентрациями наночастиц. Полученные экспериментальные данные показывают что примеси наночастиц влияют на параметры фазового перехода твердое тело – жидкость, а также на теплоемкость изопропилового спирта. Наибольшее влияние наночастиц на параметры перехода наблюдается при низких концентрациях оксида алюминия. Авторами предложена новая методология определения температуры плавления, основанная на нахождении минимума производной функции, описывающей полученную термограмму.

Ключевые слова: наночастицы, изопропанол, теплоемкость, температура плавления.

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Al_2O_3 нанобөлшектерінің изопропанолдың калорикалық қасиеттеріне әсерін зерттеу

Бұл жұмыстың мақсаты концентрациясы әртүрлі нанобөлшектермен алюминий оксидінің нанобөлшектерімен изопропил спирті – наножүйесінің моделінің калорикалық қасиеттерін тәжірибе жүзінде анықтау болып табылады. Алынған тәжірибелік мәліметтер нанобөлшектердің қоспалары қатты дене – сұйықтық фазалық ауысуының параметріне, сонымен қатар изопропил спиртінің жылусыйымдылығына әсер ететінін көрсетеді. Нанобөлшектердің ауысу параметріне айтарлықтай көп әсері алюминий оксидінің төмен концентрациясында байқалады. Авторлар алынған термограмманы сипаттайтын функцияның туындысының минимумын анықтауға негізделген балқу температурасын анықтаудың жаңа әдістемесін ұсынған.

Түйін сөздер: нанобөлшектер, изопропанол, жылусыйымдылық, балқу температурасы.

The aim of this work is the experimental studying the caloric properties of the model nanosystems – isopropyl alcohol with nanoparticles of alumina oxide (Al_2O_3) at different nanoparticle concentrations. Study of thermophysical properties of these model systems is required to assess the of nanoparticle's influence on the phase equilibria parameters and heat caloric properties of working fluids and coolants with nanoparticle additives promising for use in refrigeration systems.

The results obtained for the temperature of phase transition (melting) and heat capacity

for the nanofluids are reported in this paper. The components of solution were isopropanol and nanoparticles Al_2O_3. Nanofluid samples have been prepared by dilution of the serially produced nanoalcohol sample (CAS Number 1344-28-1) with the pure isopropanol. The size of nanoparticles in the nanofluid samples did not exceed 50 nanometers. The measurements have been done using experimental calorimetric setup that realizes the direct heating method. Melting temperature definition was performed by the thermogram method. The direct heating method in a calorimeter with a quasi-adiabatic cover was used for determination of the heat capacity of nanofluids.

The obtained experimental data show that nanoparticle admixtures influence on parameters of phase transition solid – liquid and the heat capacity of isopropyl alcohol as well. The results show that the presence of nanoparticles affects the parameters of the solid-liquid phase transition. The greatest effect of nanoparticles on the parameters of the phase transition appears at low concentrations of Al_2O_3. The authors proposed a new methodology to determine the melting temperature. This methodology based on the finding the minimum derivative of the function describing the obtained thermogram.

The analyzes of the obtained results shows that our experimental heat capacity data for the isopropanol are in good agreement with the reference information and other literature data. The additive (0.88 %) of Al_2O_3 nanoparticles to the pure isopropanol leads to changes in absolute value of the heat capacity at constant pressure. The effect was approximately 5% heat capacity decrease in the liquid phase and about 5% increase in the solid phase compared with the heat capacity of pure alcohol. This result should be considered as quite reasonable, because the alcohol molecules are adsorbed on the surface of nanoparticles and form the stable micelles. Thus, the structure of colloidal solution in the liquid phase is more ordered compared with the structure of pure alcohol, which leads to a reduction of heat capacity in the liquid phase. The question of the effect of nanoparticle concentration on isobaric heat capacity of isopropyl alcohol requires additional studies. This research is currently under way in the laboratory of the «Thermophysics and Applied Ecology» Department, Odessa National Academy of Food Technologies.