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Physico-chemical properties of the pseudo-binary mixture gasoline + 1 - butanol

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Abstract

Biobutanol can be a good biofuel candidate to contribute to CO_2 reduction. Used as a direct substitute of gasoline or as a fuel additive, biobutanol is a better candidate than bioethanol due to its higher energy density and lower tendency to absorb water than ethanol. The properties of gasoline + biobutanol mixtures are very important because they influence production, transportation, and distribution processes as well as all processes that take place in the internal combustion engine. Densities, viscosities and refractive indices have been measured over the whole composition range for gasoline + 1 - butanol mixtures at T = (293.15, 298.15, 303.15, 313.15, and 323.15) K for density and viscosity and at 293.15 K for refractive index, and at atmospheric pressure. Based on experimental data, the accuracy of different equations has been tested to predict the density, viscosity, and refractive index of the pseudo-binary gasoline + 1 - butanol mixtures. Deviations in viscosity and refractive index have been calculated and fitted to the Redlich-Kister equation to obtain the regression coefficients and standard errors between experimental and calculated results. The experimental and calculated quantities are used to understand the behavior of investigated mixture of fuels.

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Keywords: biobutanol; gasoline; density; viscosity; properties prediction

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1. Introduction

Biofuels penetration on the fuel market is explained by the determination to reduce environment pollution [1–6]. Transportation sector is one of the largest sources of environmental pollution [7]. Taking into account the need of biofuels diversification [8, 9], beside bioetanol and biodiesel, the two biofuels already imposed on the fuel market, biobutanol can be a good biofuel candidate to contribute to CO_2 reduction [10–13]. Used as a direct substitute of gasoline or as a fuel additive, biobutanol is a better candidate than bioethanol due to its higher energy content and lower tendency to absorb water [11, 14]. The properties of gasoline + biobutanol mixtures are very important because they influence production, transportation, and distribution processes as well as all processes occurring in the internal combustion engine. To the best of our knowledge there are not many studies regarding gasoline + butanol blends and they are focused especially on engine performance and emissions and less on the physico-chemical properties of these blends. Butanol added to gasoline improves combustion stability, can increase octane rating and reduces CO and NOx emissions [10, 11, 15–18]. In this paper, density, viscosity and refractive index of gasoline + 1 - butanol mixtures have been reported over the whole composition range and for temperature ranging from 293.15 to 323.15 K for density and viscosity and at 293.15 K for refractive index. Based on experimental data, the accuracy of some equations to predict the density, viscosity and refractive index of the studied mixtures with butanol, has been tested. Deviations in viscosity and refractive index were derived from measured viscosities and refractive indices and were used to understand the behavior of these mixtures. Literature survey showed that these binary data have not been published before.

Nomenclature

a, b, c	adjustable parameters
A_i	parameters of Redlich-Kister correlation
AAD	absolute average deviation
G_{12}	interaction parameter
k	number of calculated/ experimental values
n_D	refractive index of the mixture
n_{Di}	refractive index of component i
T	temperature
Y	mixture property
Y_{calc}	calculated value of the property
Y_{exp}	experimental value of the property
φ_i	volume fraction of component i
ρ	density of the mixture
ρ_i	density of component i
η	kinematic viscosity of the mixture
η_i	kinematic viscosity of component i
w_i	mass fraction of component i

2. Experimental

2.1. Experimental set-up

N-Butanol was purchased from Chimopar Company (mass fraction > 0.97), gasoline was supplied by a local company. Some properties of gasoline and n-butanol are presented in Table 1. Five binary mixtures were prepared from the two constituents by weighing (0.0999, 0.1999, 0.4001, 0.5999 and 0.8007 mass fraction of gasoline) using a Kern analytical balance ABJ type with a precision of ± 1 x 10^{-4} g. The volume of the two constituents from each sample has been measured with a precision pipette (± 0.01 cm^3), before weighing. Cautionary measures were taken to avoid exposure to air and evaporation. The samples were kept in tightly closed bottles. In order to ensure the