Data on kinetic, energy and emission performance of biodiesel from waste frying oil

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Abstract

The data presented in this article are related to the research article “Environmental and techno-economic considerations on biodiesel production from waste frying oil in São Paulo city” (Silva Filho et al., 2018) [1]. This article presents the variation of the concentration of waste frying oil (WFO) with the reaction time and temperature during the transesterification of WFTs collected in the residences and restaurants of the city of São Paulo. Then, the biodiesel samples were mixed with the S-10 diesel oil in order to obtain the B10, B20, B30, B40, B50, B75 and B100 blends, which were tested in a diesel engine and their power, fuel consumption and gas emissions (CO, CO₂ and SO₂) have been measured to verify their greenhouse effect and energy efficiency.

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## Specifications Table

| Subject area          | Environmental Science |
|-----------------------|-----------------------|
| More specific subject area | Biofuel and energy |
| Type of data          | Tables                |
| How data was acquired | Gas analyser, energy controller, power generator, liquid-liquid extraction. |
| Data format           | Raw and analysed      |
| Experimental factors  | Residence and restaurant waste frying oils were transesterified with ethyl alcohol under the time and temperature effects and the effects on the energy efficiency and greenhouse gas of seven blends of these biodiesels were verified. |
| Experimental features | The relation between the waste frying oil source with the reaction time and temperatures and their biodiesels with the generation of energy and emission of greenhouse gases |
| Data source location  | School of Chemical Engineering of State University of Campinas from Campinas and Industrial Engineering Post Graduation Program of Nine July University from São Paulo, Brazil |
| Data accessibility    | The data are available with this article |
| Related research article | Silva Filho, S. C.; Miranda, A. C.; Silva, T. A.; Calarge, F. A.; Souza, R. R.; Santana, J. C. C.; Tambourgi, E. B. Environmental and techno-economic considerations on biodiesel production from waste frying oil in São Paulo city. J. Clean. Prod., 183, 1034 – 1042, 2018. |

## Value of the data

- Data on transesterification kinetic also is useful to determine time temperature and composition to obtain high-quality biodiesel from waste frying oil;
- Data on Biodiesel greenhouse gases emission is useful to compare to emission of other fuels;
- Data on biodiesel energy efficiency is a good indicator to choose the best biodiesel blends to use in power generation.

## 1. Data

The data showed in this article is related to the research article by Silva Filho et al. [1], which made comparison energy and gas emission efficiencies between biodiesel blend and diesel oil. Biodiesel was obtained from waste frying oil from restaurant and residences of city of São Paulo, Brazil.

## 2. Experimental design, materials, and methods

This analysis was performed in a jacketed reactor and 100 mL total volume, into which we added 50 mL of oil and 8.33 mL of alcohol and mixed them in the reactor (6:1 volumetric ratio). The reactions proceeded at temperatures of 40 °C, 50 °C, 60 °C, 70 °C, and 80 °C, with 0.1% NaOH (m/v) as a catalyst during constant stirring for up to 120 min. Measurement of the biodiesel amount formed was carried out every 10 min by decanting into a separating funnel; the light phase was washed with petroleum ether and separated in a Soxhlet extractor [2]. Full data are showed in Tables 1 and 2. After adjusting the kinetic data to a model, the parameters presented in Table 3 were generated and used to calculate the activation energy, assuming a batch stirred tank reactor and zero-order models were
tested, by means of the concentration ($C_A$) of waste frying oil. This way, adjustments were made to find the kinetic constant ($k$) and the initial concentration ($C_{A0}$). After determination of the kinetic constants, activation energy ($E_a$) of the transesterification reaction was calculated based on the linearised Arrhenius equation. All fitting model were evaluated of according to [3,4].

The energy data generated after the combustion of the oil in the generator, as well as fuel consumption and efficiencies are shown in Table 4. The resultant residential and restaurant biodiesels were mixed in these proportions, and their blends in diesel oil ranging from 10% to 100% were tested on a diesel engine. Thus, we conducted a comparison of their energy and greenhouse gas emission

### Table 1
Data on concentration and yield of the transesterification of the waste frying oil from residences.

| Time (min) | 40 °C | 50 °C | 60 °C | 70 °C | 80 °C |
|------------|-------|-------|-------|-------|-------|
|            | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) |
| 0          | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 |
| 10         | 0.7294 | 17.14 | 0.8053 | 8.383 | 0.8303 | 5.76  | 0.6934 | 21.20 | 0.7807 | 11.36 |
| 20         | 0.5456 | 37.86 | 0.6579 | 25.20 | 0.6395 | 27.27 | 0.4703 | 46.35 | 0.6377 | 27.48 |
| 30         | 0.4113 | 53.00 | 0.5365 | 38.89 | 0.4958 | 43.48 | 0.2059 | 76.15 | 0.5248 | 40.21 |
| 40         | 0.2712 | 68.79 | 0.4140 | 52.70 | 0.3985 | 54.44 | 0.1578 | 81.58 | 0.0247 | 96.57 |
| 50         | 0.1548 | 81.91 | 0.3048 | 65.00 | 0.1777 | 79.33 | 0.0247 | 96.57 | 0.0262 | 96.41 |
| 70         | 0.0366 | 95.23 | 0.1570 | 81.67 | 0.0220 | 96.88 | 0.0410 | 94.73 | 0.0187 | 97.26 |
| 80         | 0.0292 | 96.06 | 0.0213 | 96.96 | 0.0027 | 99.69 | 0.0586 | 92.75 | 0.0427 | 94.55 |
| 120        | 0.0001 | 99.89 | 0.0396 | 94.89 | 0.0058 | 98.71 | 0.0476 | 94.00 | 0.0108 | 99.88 |

### Table 2
Data on concentration and yield of the transesterification of the waste frying oil from restaurants.

| Time (min) | 40 °C | 50 °C | 60 °C | 70 °C | 80 °C |
|------------|-------|-------|-------|-------|-------|
|            | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) | $C$ (mol/L) | Yield(%) |
| 0          | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 | 0.8815 | 0.000 |
| 10         | 0.8141 | 7.600 | 0.8223 | 6.072 | 0.6863 | 20.04 | 0.5444 | 34.61 | 0.5319 | 35.89 |
| 20         | 0.7617 | 13.50 | 0.7514 | 13.36 | 0.6331 | 25.50 | 0.4557 | 43.72 | 0.3429 | 55.30 |
| 30         | 0.5089 | 42.00 | 0.7218 | 16.39 | 0.4645 | 42.81 | 0.3048 | 59.20 | 0.2664 | 63.15 |
| 40         | 0.3847 | 56.00 | 0.5118 | 37.95 | 0.2960 | 60.12 | 0.0476 | 85.61 | 0.0195 | 88.50 |
| 50         | 0.2876 | 66.94 | 0.1556 | 74.52 | 0.0653 | 83.79 | 0.0209 | 88.43 | 0.0262 | 87.77 |
| 70         | 0.0292 | 96.06 | 0.0213 | 96.96 | 0.0027 | 99.69 | 0.0586 | 92.75 | 0.0427 | 94.55 |
| 120        | 0.0001 | 99.89 | 0.0396 | 94.89 | 0.0058 | 98.71 | 0.0476 | 94.00 | 0.0108 | 99.88 |

### Table 3
Data to calculate the activation energy ($AE$) by Arrhenius method.

| $T$ (°C) | Residence frying oil | Restaurants frying oil |
|----------|-----------------------|------------------------|
|          | $k$ ($10^{-4}$ mol/s) | $T$ (K) | $k$ ($10^{-4}$ mol/s) | $T$ (K) |
| 40       | 1.817                 | 313.15 | 1.750                 | 313.15 |
| 50       | 2.033                 | 323.15 | 2.283                 | 323.15 |
| 60       | 2.450                 | 333.15 | 2.483                 | 333.15 |
| 70       | 2.933                 | 343.15 | 2.833                 | 343.15 |
| 80       | 3.283                 | 353.15 | 3.317                 | 353.15 |
efficiency rates in relation to diesel oil marketed in Brazil at the time of the design of this study. These data were used by Silva et al. [1] to calculate the energy generation efficiencies, fuel consumption to determine the best biodiesel blend to be used in electric generators without losing the efficiency of converting the fuel to electric energy.

Table 5 shows average values of gases measured in this work. The CO, CO₂, and SO₂ amounts were measured every 2 s via insertion of the BEA720 gas analyser sensor (Bosch Ltd®) into the gas outlet duct of the power generator engine. Measurements were taken during power generation using diesel oil and biodiesel blends of 10, 20, 30, 40, 50, 75 and 100% purity. These measurements were used to compare the gaseous emissions of biodiesel samples with the control (diesel oil), as shown in Silva et al. [1].

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Transparency document. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.04.017.
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