**Authors’ Response to Review Comments**

***Journal:*** JSCS, Journal of the Serbian Chemical Society

***Manuscript #:*** 3035

***Title of the Paper:*** Extractive purification of hydrotreated gas oil with N-methylpyrrolidone

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***Date Sent:***  November 21, 2016

We thank the Referees for their interest in our work and for helpful comments that will greatly improve the manuscript and we have tried to do our best to respond to the points raised.

As indicated below, we have checked all the comments provided by the Referees and have made necessary changes accordingly to their indications; we hope that the revised version can meet the journal publication requirements.

**Comment 1:**

*In addition to conventional hydrodesulfurization there are some others alternative desulfurization methods such as selective adsorption, biodesulfurization, and oxidation/extraction. In my opinion authors should include in introduction part some important reviews about others desulfurization technology like:*

*I.V. Babich, J.A. Moulijn Science and technology of novel processes for deep desulfurization of oil refinery streams: a review, Fuel 82 (2003) 607–631*

*Vimal Chandra Srivastava, An evaluation of desulfurization technologies for sulfur removal from liquid fuels, RSC Advances, 2012, 2, 759–783*

**Response:**

Thanks for the suggestion; we agree with the reviewer that there are some others alternative desulphurization methods which have been the subject of recent researches, the inclusion of these methods in the introduction part will make it more complete.

In the revised manuscript, we have added the description of the main processes: oxidative desulphurization on page 2, desulphurization by adsorption on page 2, biodesulphurization on page 3 and extractive desulphurization on page 3. The proposed reviews have been indexed as references N° 9 and N° 10.

**Comment 2:**

*Authors state that the sulphur concentration of extracts is deducted from the material balance. Authors should explain how they determined refractive index and density for extracts. In my opinion values for extracts density are too high.*

**Response:**

Thanks for the comments. The refractive index of rafinates and extracts was determined by a classic Abbe Refractometer at room temperature, the obtained values have been adjusted to the standard temperature of 20 °C using the formula (1) given above.

*nD20 = nDT + 0.00045 (T - 20 oC)*

The density of the rafinates and extracts was measured using the electronic densimeter ANTON PAAR type DMA 48 at 15 °C. These explanations have been added to the revised manuscript in the part of RESULTS AND DISCUSSION (page 5).

A comment about refractive index value of raffinate No. 8 was added on page 6.

Indeed, the density of the extracts is higher compared to the density of the raffinates. In the process of extraction, there is formation of two phases:

* Raffinate phase which is rich in oil and poor in solvent
* Extract phase which is rich in solvent and poor in oil

The difference of density between these phases allows their separation by decantation. The values of density for extract phase (rich in solvent) are near that of N-methylpyrrolidone which is of 1.028 g mL-1 at 25 °C. To clarify this point, more details have been added in the EXPERIMENTAL part (pages 4 and 5) and in the part of RESULTS AND DISCUSSION (pages 5 and 6).

**Comment 3:**

*Authors state that a best results was obtained in the experiment No. 8 carried out on five-stage at 40°C. (Line 117). In experiment No. 8 authors really obtained best degree of sulfur removal but yield of raffinate is relatively low. I think that authors should discuss their results also from economic point of view of a process. In experiment 7 they obtained good degree of sulphur extraction (7 ppm higher content than in experiment 8) but yield of raffinate is significantly better than in experiment 8 (95 : 81%).*

**Response:**

The authors agree with the opinion of reviewer. A comparison between experiments No. 7 and No. 8 was added in the revised manuscript (page 7). In experiment No. 7, we lose lower fuel and lower energy for recycling solvent. Experiment No. 7 could be more economical, from the point of view of process, than experiment No. 8.

We have selected raffinate No. 8 for further analysis because it approaches European standard (EN 590) with the lowest sulphur content and the lowest refractive index (page 7).

 A comment concerning the European, Russian and Algerian standards was added in CONCLUSION section.

**Comment 4:**

*Kumar and others in their papers: Removal of refractory sulfur and aromatic compounds from straight run gas oil using solvent Extraction RSC Adv., 2014, 4, 38830, and Removal of Refractive Sulfur and Aromatic Compounds from Straight-Run, Fluidized Catalytic Cracking, and Coker Gas Oil Using N‑Methyl-2-pyrrolidone in Batch and Packed-Bed Extractors Energy Fuels, 2015, 29 (7), pp 4634–4643 have obtained significantly different results on the influence of water content and temperature on the extraction efficiency. In both documents the increase of temperature increase levels of sulfur removal and decrease yield of raffinates. The authors obtained a reduction of both parameters. Similarly, in his works Kumar et al found that adding water increase raffinate yield and reduce the degree of sulfur removal. The authors receive an increase in both parameters. It will be interesting if authors could explain these differences.*

**Response:**

Thanks for the comments. We agree with the reviewer that our results do not coincide with those of Kumar et al concerning the influence of water content and temperature on the extraction efficiency. Kumar et al used other types of gasoils (SRGO, LCO, CGO) obtained by other processes. The sulphur compounds of these feeds are different from those contained in the hydrotreated gas oil.

Mokhtar et al in their paper: Deep desulfurization of model diesel by extraction with N,N-dimethylformamide: Optimization by Box–Behnken design, J. Taiwan Inst. Chem. Eng. 45 (2014) 1542, reported the same result that we have found about the impact of temperature on the desulphurization of a synthetic gas oil with DMF, the sulphur compounds selected for this study are the same nature as those present in hydrotreated gas oil. (Please see next figure)



Adzamic et al in their paper: Desulfurization of FCC gasoline by extraction with sulfolane and furfural, NAFTA. 60 (2009) 485, showed that the increase of temperature from 50 ° C reduces desulphurization efficiency (the sulphur content in raffinate increase) for sulfolane and has no significant effect on the extractive desulphurization with furfural. (Please see next figure)



The different results observed indicate that the impact of temperature and water content on efficiency of the process is related to the nature of the sulphur compounds present in the feedstock, the composition and the origin of the petroleum fractions determine the choice of the solvent and the operating parameters of the process.

These comments have been added in the part of RESULTS AND DISCUSSION (pages 7 and 8). The articles of Kumar et al, Mokhtar et al and Adzamic et al have been indexed in the revised manuscript as references N° 20, 21, 22 and 23.

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