NEW ESTIMATES OF MASS LOSSES IN BIODEGRADED OILS USING PETROLEUM DISTILLATION DATA

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Petroleum biodegradation includes a series of biologic processes that cause a preferential removal of some compounds by bacterial attack on a pristine oil under reservoir conditions. The most remarkable effects of biodegradation involve loss of light ends and a relative enrichment in resins and asphaltenes, and consequently an increase in petroleum density and viscosity, with a decrease in commercial value. Hence, petroleum biodegradation causes an important mass loss in the originally accumulated volumes in reservoirs. When assessing the petroleum potential of exploratory prospects by basin modelling techniques, the risk of biodegradation and its related mass loss in the estimated volumes must be considered.

Several attempts have been made to estimate petroleum mass losses by biodegradation. For example, Larter et al. (2005) estimated mass losses up to 50% in severely biodegraded oils. Such estimates are relative, since the biodegraded oil and its compound concentrations represent an unknown fraction of the original oil. Furthermore, losses of heavy compounds in the chromatographic techniques are not taken into account in the mass balances.

Petroleum distillation has been widely used for the characterization of crude oils for refining applications. It consists in submitting a crude oil to increasing temperatures with controlled pressure to ensure that no cracking occurs during the assay. With increasing temperatures, petroleum compounds are progressively vaporized according to their boiling points, and fractions are condensed in the distillation column and recovered for further chemical and physical analyses. By weighing all the petroleum fractions (distillate cuts and residue), a complete mass balance can be achieved, and cumulative mass yield curves obtained for each crude oil.

In this work, cumulative mass yield curves and distillation data have been used to estimate mass losses due to biodegradation. Distillation assays have been undertaken for several pairs of biodegraded oil and its non-biodegraded counterpart from Brazilian marginal basins. As expected, a comparison of their distillation curves clearly shows that non-biodegraded oils are enriched in the lighter fractions, whereas the percentage of residue is greater in the biodegraded oil (Fig. 1).

Starting with the cumulative mass yield curve of the non-biodegraded oil, percent losses can be assigned individually to distillation cuts so that a curve simulating biodegradation effects matches that of the biodegraded oils. From the matched curve, the renormalized mass percentages of each “degraded” cut and residue, and their respective densities, can be used to calculate the density of the whole biodegraded oil by a weighted average. To achieve a proper match of both simulated distillation curve and calculated density as a result of biodegradation, the following changes are deemed to occur in the non-biodegraded oil (Fig. 2): 1) preferential loss of lighter cuts; 2) increase in density of cuts (ca. 3%); and 3) absolute increase of the residual fraction, not just by relative enrichment. Whereas the first and the second conditions are straightforward, our mass balances unexpectedly indicate that incorporation of heavy compounds in the residue is necessary to account for a correct density of the biodegraded oil. In our investigated cases, the 550°C+ residues in the biodegraded oils increase from 20 up to 70% in absolute terms when compared to their non-biodegraded precursors, whereas the light fractions (C_{14-}) might be lost in the 50-100% range. Overall, mass losses of the biodegraded oil have been estimated to be from 8 to 30%, depending on the composition and maturity of the original non-biodegraded oil.

In conclusion, a method for the estimation of mass losses in biodegraded oils has been developed using petroleum distillation data. The fact that it allows a complete mass balance of the oil, including its heaviest components, constitutes its main advantages compared to other methods that provide only relative estimates. Results obtained with this new method indicate that overall mass losses are lower than those previously estimated because an incorporation of heavy compounds in the oil residue is necessary for oil density calibration.

REFERENCES

Larter, S. R., Head I. M., Huang H., Bennett B., Jones M., Aplin A. C., Murray A., Erdmann M., Wilhelms A., and di Primio R., 2005. Biodegradation, gas destruction and methane generation in deep subsurface petroleum reservoirs: an overview. In: Dore A. G., Vining B., (Eds.), Petroleum geology: Northwest Europe and global perspectives. Proceedings of the 6th Petroleum Geology Conference, Geological Society (London), pp. 633–640.

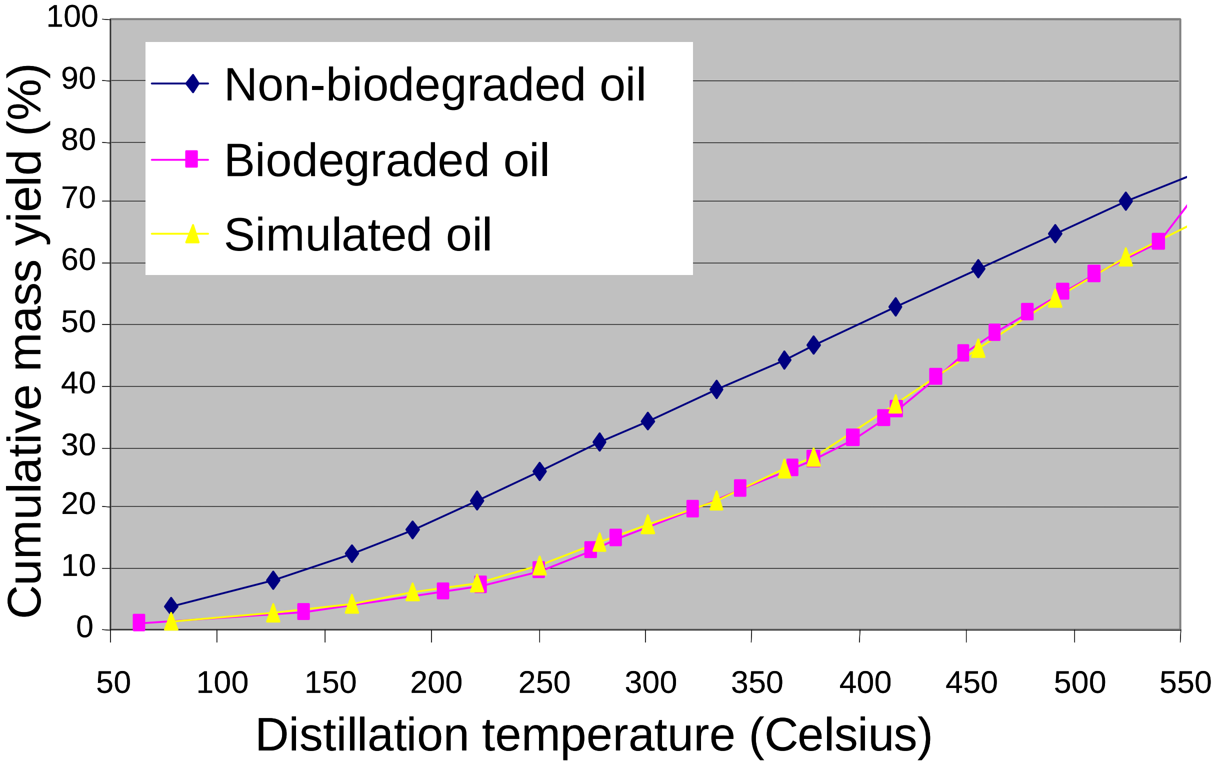

Figure 1: Cumulative mass yield curves of the non-biodegraded, biodegraded and simulated oils.

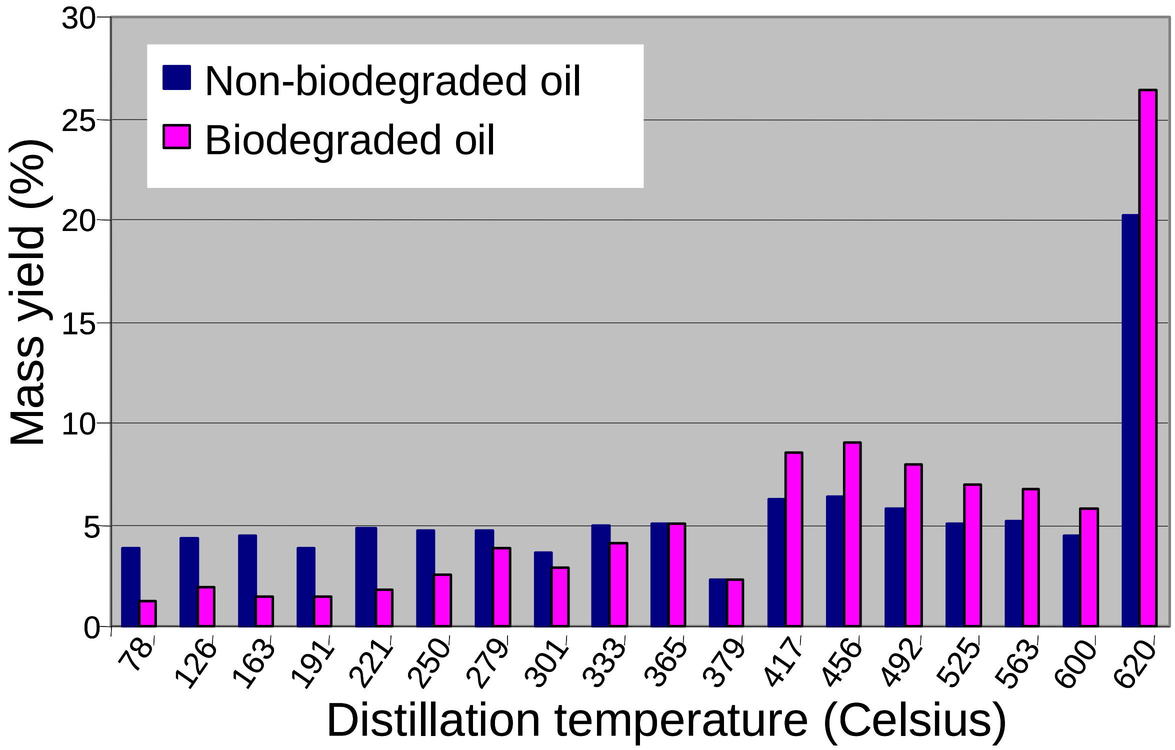

Figure 2: Mass yields (%) of the distillation cuts in the non-biodegraded and biodegraded oils.