FATE OF HEAVY METALS DURING THERMOCHEMICAL TREATMENTS OF CONTAMINATED BIOMASS

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As industrial production continues to expand, land pollution is becoming a huge threat to environmental safety and, consequently, there is an increasing need for soil remediation techniques.

In latest years, a new environmental remediation technique, that is phytoremediation, is growing in importance and diffusion around the world, both for its low economical cost and for the non-use of chemical products.
Phytoremediation involves the cultivation of specific vegetable species on soils contaminated by heavy metals, that are capable to extract metals from the soils and concentrate them into plant tissues. The main issue that raises with phytoremediation is how to treat and dispose of the produced heavy metals contaminated biomass.
Pyrolysis is getting more and more attention as a thermochemical treatment for these contaminated biomasses as it has two main beneficial effects: through pyrolysis the volume of the biomass is greatly reduced, so its handling and disposal are simplified; moreover, pyrolysis is also a valorization technique, since it can generate valuable products, such as bio-oil and biochar, from waste biomass.

In general, it is known that the distribution and the exact composition of all the pyrolysis products depend both on the feedstock biomass properties and on the operative conditions of the process. The main parameters that influence the outcome of pyrolysis are final temperature, heating rate and, to a less extent, the residence time of the biomass; their combination defines the pyrolysis regime that occurs.

However, the presence of metals in the lignocellulosic biomass structure creates non-negligible complications during pyrolysis, both regarding the possible catalytic effect of metals during biomass thermal decomposition and physical-chemical transformation of heavy metals themselves, associated with their distribution in different pyrolysis product. By choosing the right combination of pyrolysis operative conditions it seems possible to concentrate most part of heavy metals into the biochar, obtaining a clean bio-oil that can be further processed. Anyway, this aspect is still not well known.

This Ph.D. thesis focuses on studying how different operative conditions influence the behaviour of heavy metals in lignocellulosic contaminated biomass pyrolysis. In general, transfer mechanisms are strongly dependent on the specific inorganics, the initial biomass chemistry and associated structural changes at particle level. Temperature can be properly tuned to avoid evaporation of the most common heavy metals (Pb, Zn, Cu and Cd). However, the release of certain elements depends also on reactor design. Moreover, most studies address separately the two beneficial aspects of pyrolysis applied to contaminated biomass (immobilizing heavy metals into high quality biochar and obtaining a clean, inorganic-free bio-oil), optimizing the conditions for each specific target product independently.

The aim of this thesis is to establish a systematic approach to study the effect of several operating and technological parameters on the fate of heavy metals through the design and setup of different experimental systems, in order to be able to investigate various pyrolysis regimes. The pyrolysis process will be monitored in situ (e.g. through optical diagnostic) and pyrolysis products will be characterized off-line, with the aim of understanding the chemical and phase transformations that occurs to heavy metals during thermochemical treatment.

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