Application of the pyrolysis technology for industrial and hazardous waste management

K. Triantafyllidis[1,*], P. Samaras[2], G. Palantzas[3], E. Tzamos[4], A. Zouboulis[1]

[1] Department of Chemistry, A.U.Th., Thessaloniki, 54124, Greece
[2] Department of Food Technology, ATEI of Thessaloniki, Thessaloniki, 57400, Greece
[3] Department of Civil Engineering, A.U.Th., Thessaloniki, 54124, Greece
[4] North Aegean Slops S.A., R&D Department, Thessaloniki, 54627, Greece
1 Department of Chemistry, A.U.Th., Thessaloniki, 54124, Greece

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* Presenting author email: *ktrianta@chem.auth.gr*

ABSTRACT

The treatment, management, recovery and disposal of industrial and hazardous waste are common concerns worldwide. In Greece, such types of wastes are considered as an integral part of the immediate priorities and strategies of both the National Hazardous Waste Management Plan (NHWMP) and the respective Regional Waste Management Plans. According to the NHWMP, the recovery rate of hazardous industrial wastes is today almost 33%, with a target to reach at 45% by 2020, while more than 60% of them is currently driven directly for storage and disposal. From the latter quantity, around 29% is shipped abroad. It is also mentioned that Greece should have the necessary networks and facilities to manage 124,000 tonnes of hazardous industrial waste, while a significant amount (over 500,000 tonnes) is stored "historically" in their production (industrial) areas. Regarding the non-hazardous industrial wastes, which are mainly generated from energy processing and production units, they should be driven for recovery and disposal at 25% and 75% respectively, with emphasis on industrial sludges, for which a maximization of recovery possibility is required.

According to the Directive 2008/98/EC, "the following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy: prevention; preparing for reuse; recycling; other recovery, e.g. energy recovery; and finally, disposal". Thus, it becomes clear that the use of landfills must be considered only for the final (non-recoverable) residuals, while the re-use and recycling options should be mainly focused at pursuing the effective material recovery. For those streams of wastes, for which the material recovery is not effectively applicable, the energy recovery is the path to be followed, considering also that when applying the waste hierarchy, measures to encourage the options delivering the best overall environmental outcome, should be also applied.

The spread of pyrolysis technology, mainly for the industrial and hazardous waste treatment seems to be quite limited and not adequately tested in commercial applications, and there are no published results, concerning specifically the use of this method e.g. for the treatment/management of industrial sludges (especially the oily ones), as well as for the empty packaging of hazardous substances (e.g. dyes) and for the waste wood, impregnated with hazardous substances for conservation purposes (e.g. for railway lines). Noting also, that considering urban and non-hazardous wastes, some countries, such as Japan, have developed relevant plants, based on pyrolysis process, while in European Union, it is known that there is mainly one big, industrial operational facility (Burgau, Germany). Individual smaller-size applications within certain manufacturing/processing plants already exist in various countries, also in Greece, mainly for the processing of animal by-products (e.g. from slaughterhouses).

Based on these information, a research project entitled "Application of the pyrolysis technology for industrial and hazardous waste management" has been selected for funding through the Single RTDI State Aid Action "RESEARCH–CREATE–INNOVATE", within the frame of the Operational Programme "Competitiveness, Entrepreneurship and Innovation 2014-2020 (EPAnEK)". The main aim of the project is the development of a relatively innovative method for the management of specific streams of industrial and hazardous waste, by applying pyrolysis in laboratory, as well as in pilot-scale installations. The relevant waste streams, where the research will focus, are: (a) sludges and sediments (such as those, oily/hydrocarbon residuals), (b) packaging wastes, containing residues of hazardous substances (e.g. residual dyes), (c) wood wastes, containing hazardous substances (e.g. used for wood conservation).

The project end-user is NORTH AEGEAN SLOPS S.A., a company that has long-term experience in collection and transport of such wastes, especially those originating from ships, and aims to use the project's results in order, among others, to exploit the relevant entrepreneurial potential, to innovatively modernize its services and to enhance its competitiveness and entrepreneurship at national and international level.

In this frame, the main content of the project is to investigate the correlation of the waste type and the respective pyrolysis conditions, at laboratory and pilot scale, with the qualitative and quantitative characteristics

of the product streams (e.g. biochar, scrap, oil, steam, hot water, exhaust gases) in the direction of technical and economic optimization of the proposed method. The feasibility of developing and promoting the method on a commercial scale will be evaluated through the elaboration of a relevant study.

More particular, at a laboratory level, a micro-pyrolytic unit linked to GC-MS and a bench-scale fixed bed unit will be used to investigate the effects of different raw materials (i.e. the type and composition of waste) and the respective pyrolysis conditions (e.g. temperature, residence time) on the qualitative and quantitative characteristics of the solid, liquid and gaseous products (e.g. biochar, oil, exhaust fumes), using rather small quantities from the waste. Gas sampling will be performed in order to determine their content of conventional pollutants, such as sulphur oxides and nitrogen oxides and to compare these values with the corresponding legislative limits, but also to assess the capacity to produce heat through their combustion. Bio-oil, another interesting by-product, will be also analysed to identify its composition and the possibilities of mixing it with other bio/fuels, or for its direct use as an alternative fuel. Biochar will be also examined/evaluated for its subsequent re-use.

At a pilot-scale level, through the construction and operation of a pyrolysis oven with 300-500 L capacity, the various operational conditions will be tested in order to define the ratio of operation-recycling of materials and to optimise the energy recovery. The produced biochar will be examined for its adsorption capacity towards the removal of some organic pollutants (e.g. colours), as well as for its agronomic characteristics, regarding soil/fertilizer applications. In addition, the quantity and temperature of the resulting water (from the steam production) will be investigated, as well as the steam dynamics in the direction of use in gensets for electricity generation. Analyses will be also performed, regarding the scrap produced from the empty packages through the application of pyrolysis process, for assessing its qualitative characteristics in terms of re-use in steel plants.

Therefore, this work will investigate the use of the pyrolysis process in the management of particular hazardous and industrial wastes, in terms of laboratory and pilot-scale level evaluation experiments, focusing on the obtained products and potential pollutants resulting from the process, and the possible applications of the products and the measures to control the associated environmental effects. The final aim of this paper is to provide updated information and results on the application of pyrolysis process for the management of hazardous industrial wastes and to evaluate its potential as a waste-to-energy conversion technology.

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