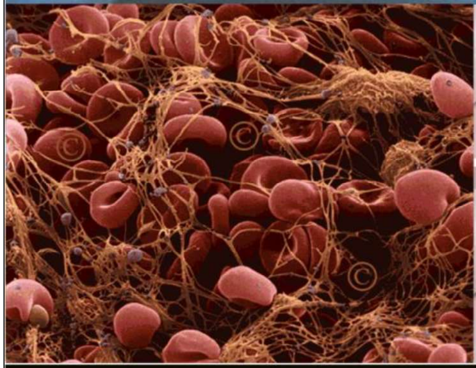
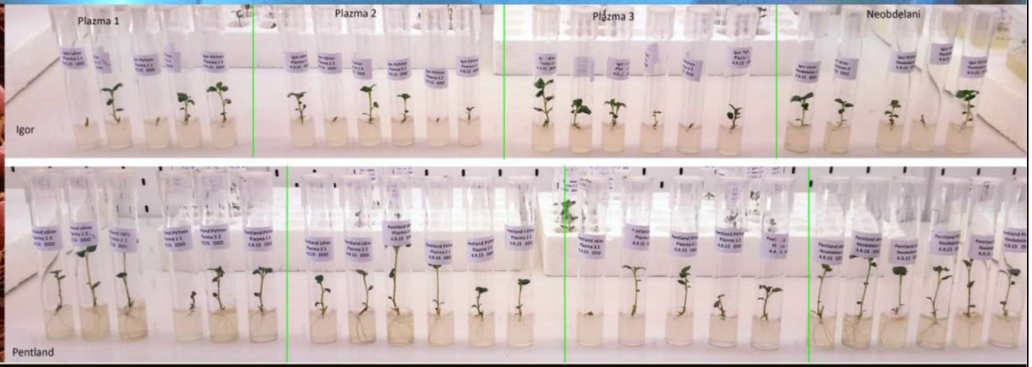
8th Central European Symposium on Plasma Chemistry





26th to 30th May 2019, Gozd Martuljek, Slovenia

This abstract book is only available for the participants of the 8th Central European Symposium on Plasma Chemistry, 26th May to 30th March 2019 and is not for sale.
Publisher: Plasmadis Ltd, Teslova ulica 30, 1000 Ljubljana, Slovenia,
https://www.plasmadis.com, on electronic media (USB key in PDF format), 60 copies

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

533.9(082)(0.034.2)

CENTRAL European Symposium on Plasma Chemistry (8 ; 2019 ; Gozd Martuljek)
[Eighth]
8th Central European Symposium on Plasma Chemistry, 26th to 30th may 2019, Gozd Martuljek, Slovenia [Elektronski vir]. - Ljubljana : Plasmadis, 2019

ISBN 978-961-94716-0-9
COBISS.SI-ID 300039936

Oral

Naphthalene removal by plasma combined with various catalysts

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Non-thermal plasma has been used in numerous environmental applications, mainly for air and water pollution control. The plasma processing usually possesses decent removal efficiency, but low selectivity and high energy consumption. A combination of plasma and catalyst utilizes the individual benefits of the plasma and the catalyst and is characterized by synergistic effects. Naphthalene is polycyclic aromatic compounds and a representative component of biomass and municipal solid water tars and one of the most difficult tars to decompose. Commercial methods for tars removal include wet scrubbers, electrostatic precipitators, thermal or catalytic cracking methods. Plasma methods have been also tested and are quite well documented. However, tars removal by a combination of plasma with catalyst have been reviewed only by few papers, with toluene being the most common target tar compound.

The objective of this work was to investigate naphthalene removal by plasma generated by atmospheric pressure DBD in combination with packing materials of various shape, size, specific surface area and catalytic activity (glass beads, g-Al_2O_3 TiO_2, $BaTiO_3$, ZrO_2, Pt/Al_2O_3). Effects of specific input energy (SIE, up to 1000 J/L) and carrier gas (nitrogen, oxygen, ambient air) were also investigated. In contrast to the existing works, we performed our experiments at a relatively low temperature (below 150 °C) and high initial concentrations (5000 ppm). Gaseous and solid by-products of naphthalene decomposition were analyzed by FTIR spectrometry.

The results showed the carrier gas and packing material had very small or almost negligible effect on the SIE, respectively. Naphthalene removal efficiency (NRE) increased with the SIE and was higher for all plasma catalytic reactors in comparison with plasma alone. The carrier gas significantly affected the NRE, as different reactive species were formed. In nitrogen, $N_2(A)$ or N dominates, while in oxygen it is rather $O(^3P)$, $O(^1D)$ and O_3. In nitrogen, the NRE was relatively small (<25%) with N-containing aromatic compounds being the main by-products. In ambient air, the NRE was significantly higher (up to 88%) and accompanied by the formation of CO/CO_2 and O-containing hydrocarbons. In oxygen, complete naphthalene removal was achieved due to improved oxidation governed by O and O_3. The highest NRE was reached with TiO_2 catalyst (88%, 320 J/L). The NRE with the Pt/g-Al_2O_3 catalyst was only slightly lower, but shown much higher CO_2 concentration suggesting the best complete oxidation abilities among the materials. $BaTiO_3$ and ZrO_2 also showed relatively high NRE. Materials without specific catalytic properties (glass beads, g-Al_2O_3) showed the smallest NRE. The specific surface area and size of material played a minor role. CO, CO_2, H_2O and HCOOH were identified as by-products, as well as more complex compounds, such as 1,4-naphthoquinone and phthalic anhydride. The results proved, that combination of the non-thermal plasma with catalysis is very efficient method for naphthalene (tars) removal that allow better efficiency compared to the non-thermal plasma alone treatment.