

Identification of different kinds of plastics using laser-induced breakdown spectroscopy for waste management

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Laser-Induced Breakdown Spectroscopy (LIBS) was applied for the identification of various kinds of plastics for management and recycling of plastic waste. In order to fingerprint these plastics, a laser-produced plasma emission was recorded for spectral analysis of various kinds of plastics. The plasma was generated by focusing a Nd:YAG laser radiation at wavelength = 1064 nm having laser energy = 40 mJ. The 6 main family of plastics tested are: Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Polypropylenes (PP), Polystyrene (PS), Polyethylene Terephthalate (PET) and Polyvinyl chloride (PVC). The capability of this technique is demonstrated by the analysis of the major constituents carbon and hydrogen present in polymer matrices. The LIBS signal intensity measured for carbon and hydrogen was detrimental for the fingerprinting of various kinds of plastics. The C/H line intensity ratio was 1.68, 1.51, 1.42, 1.16, 1.01 and 0.91 for HDPE, LDPE, PS, PP, PET and PVC respectively. The detection limits of carbon and hydrogen were found to be approximately 6 $\mu\text{g/g}$ by applying 20 laser shots. The unique features of LIBS are: it is a simple, rapid, remote, real-time analysis without sampling requirements. The study demonstrated that LIBS could be applied as a best tool for sorting out different kinds plastics on a fast scale for waste management. The health hazards of different kinds of plastics are also described.

Keywords: Laser-induced breakdown spectroscopy (LIBS), plastic identification and fingerprinting, plastics recycling, environmental impacts of plastic waste.

Introduction

The worst consequence of industrial development and material production to fulfill the needs of growing world population is the deterioration of environment due to pollution of precious resources such as air, soil and water. The recycling of waste plastics has become an increasingly important issue in recent years due to the enormous use of plastics in almost every aspect of modern life. The inherent durability of most plastics is adding more to a disposal problem that affects every country in the world including Saudi Arabia. The municipal solid wastes in the cities of Saudi Arabia are being collected and managed by the City Municipal corporations (Baladia).

Most of the solid is collected without any pre-collection sorting methods. Most of this waste is dumped in a sanitary landfill, and some wastes are collected by some companies, such as aluminum, steel, plastics, etc. The dumping of these solid wastes results in the loss of reusable materials, leaching of chemicals to the groundwater, thus creating water pollution problems. Saudi Arabia is one of the major producers of plastic in the world with total production capacity of around 6 million metric tons per year. The amount of plastic wastes in Saudi Arabia is about 15 wt % in the composition of domestic municipality waste.^[1]

Plastic is being applied in many applications like households, drinking water bottles, ammunition, injection syringes, medicines containers, shopping bags etc. The untreated disposal of plastics and its effects on human health has become a matter of great concern during last decade. Plastic waste is harmful as its pigment contains many trace elements that are highly toxic. Due to these reasons, in most industrialized countries, some plastics especially colored plastics have been legally banned. Wastewaters generated by plastic waste dumped into soil or water reservoirs

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