Catalytic Solar Pyrolysis of Waste Rubber Tires

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The development of an efficient solar pyrolysis process that can achieve high conversion of tire rubber to fuel, with minimum fossil-fuel energy usage is discussed. The energy demand for pyrolysis is no longer a limiting factor and this is realized by concentrating solar radiations to drive the catalytic reaction to desired high temperatures.

Introduction

Rubber tires are made of a complex blend of polymers and non-rubber materials that makes them non-biodegradable, unrecyclable and hard to dispose of after usage. In fact, in the US alone, 52% of scrap tires are incinerated for power generation, 14% are dumped in landfills, 12% are re-used in crumb rubber products and 16% are used in construction [1-3]. However, the most serious consequence from incinerating tires is the release of high levels of dioxins, PAHs, VOCs and heavy metals. Similar to incineration, dumping scrap tires in landfills can instigate devastating fires with heavily contaminated toxic fumes. Tires in landfills can also act as a breeding hub for insects and microbes causing serious health threats to surrounding communities. Scrap tires, on the other hand, represent a cheap and readily accessible source of chemicals and fuel derivatives. Their conversion by pyrolysis can produce gaseous and liquid products of similar quality to petroleum fuel. However this usually comes at high costs. Pyrolysis operates at moderately high temperatures of 450^{o}C - 800^{o}C thus requiring large amounts of energy.

Materials and Method

Solar radiations are concentrated using a Fresnel lens integrated into an automated system to track the trajectory of the sun. Photocatalytic catalysts are employed in the pyrolysis process, under inert atmosphere, to maximize gas yield and improve liquid product slates to match gasoline range products. Catalyst characterizations for surface area, acidity and pore size are determined (TGA, BET, XRD, Ammonia - TPD) and the composition of liquid products analyzed using GC-MS.

Results and Discussion

The composite catalyst used was palladium doped on TiO_2 anatase. Both thermal and catalytic pyrolysis experiments were carried out at 590^{o}C under different catalysts. The gas yield increased from 27.27% with TiO_2 to 40.95% with Pd/TiO_2 as shown in Table 1. This came as a clear evidence of the catalytic enhancements due to palladium metal doping. The catalyst, Pd/TiO_2, is active not only under UV radiations but also under visible light range. This in turn maximized the effect of solar radiations in cracking the rubber tire. The orbital energy E_b ($Ti2_{p3/2}$) of TiO_2 is 459.2 eV and E_b ($Ti2_{p1/2}$) is 464.3 eV giving a high binding energy of $\Delta E_b = 5.1\ eV$. This binding energy shifted to a lower value of 0.7 eV when Pd is added indicating stronger photocatalytic interaction and a higher catalyst activity [3].

The effect of the catalyst is further illustrated in Figure 1 where the liquid product distribution shifted towards the gasoline range carbon chains giving higher product quality.

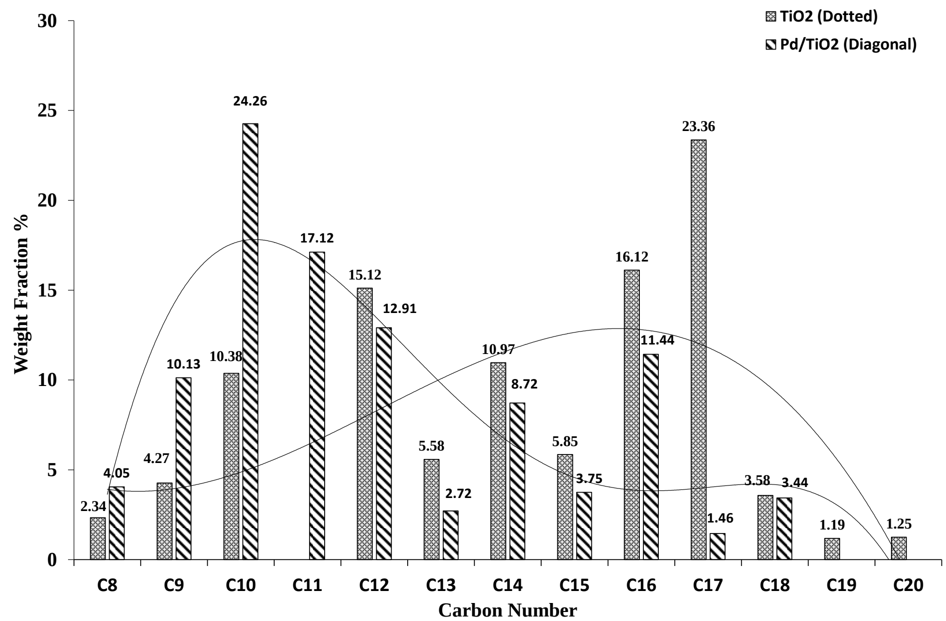

Figure 1. Liquid pyrolysis product chain distribution.

Table 1. Gas yields under different catalysts and pyrolysis conditions.

Catalyst	**Gas Yield %**	**Carrier Gas**	**Pyrolysis Type**
Blank	20.3	Nitrogen	Thermal
TiO_2	21.27	Nitrogen	Thermal
TiO_2	27.0	Nitrogen	Solar
Pd/TiO_2	40.94	Nitrogen	Solar

Conclusion

The solar pyrolysis process is successfully applied for the production of fuel gas and gasoline products from waste tires. Doping TiO_2 photo catalyst with Pd noble metal marginally improved the catalytic activity and produced 40.94% gas yield. . It is anticipated that this solar pyrolysis approach can be successfully adopted and expanded to treat general municipal solid waste.

References

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