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Experimental Analysis of the Oxidative Liquefaction of the Municipal Solid Wastes

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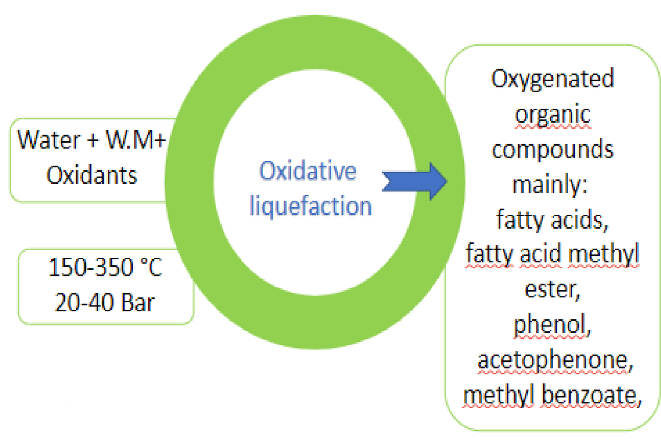
INTRODUCTION

The process of oxidative liquefaction involves reacting organic matter with oxygen or an oxygen donor at high pressures and elevated temperatures to convert it into useful liquid products. The process entails decomposing complex organic compounds into more manageable and useful chemical entities.



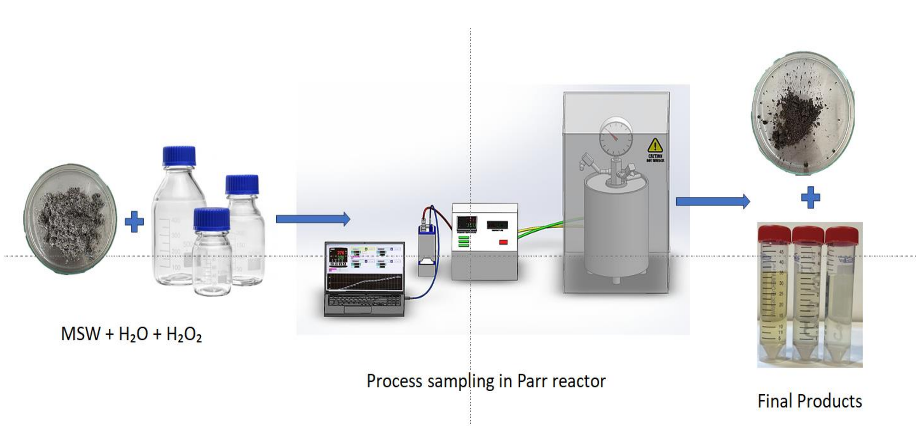
The pursuit of sustainable waste management solutions has led to the emergence of the oxidative liquefaction of municipal solid waste (MSW) as a promising approach for waste valorization.
The current research article introduces the concept of oxidative liquefaction for treating MSW.

MATERIALS, METHODS AND RESULTS

The municipal solid waste (MSW) analyzed in this study comprised a diverse and complex mixture of waste components typically found in urban and suburban areas of Poland.
The LECO TruSpec CHN and SC 632 analyzers were utilized to conduct the final analysis, aimed at determining the levels of elemental carbon, oxygen, hydrogen, nitrogen, and sulfur. The sample's total moisture, volatile matter, and ash levels were measured using a weighing method in accordance with the proper standards (CEN/TS 15414-2:2010, 2010), (EN 15403:2011, 2011), and (EN 15402:2011, 2011). The experimental protocol strictly adhered to established standards and protocols, involving high-temperature combustion coupled with infrared detection.
The results of ultimate and proximate analysis are presented in Table bellow.

Parameter	Symbol	MSW, wt%
Moisture content in the analytical state	M_{ad}	2.5 ± 0.2
Ash content in the analytical state	A_{ad}	15.1 ± 0.8
Volatile matter	VM	84.9 ± 0.3
Content of total carbon in the analytical state	C_{ad}	50.3 ± 2.3
Content of total hydrogen in the dry state	H_a	7.2 ± 0.2
Content of nitrogen in the analytical state	N_{ad}	1.1 ± 0.1
Content of oxygen in the analytical state from differences	$O_{diff.}$	23.3
Content of total sulphur in the analytical state	S_{ad}	<0.5
Content of total chlorine in the analytical state	Cl_{ad}	0.03 ± 0.01

The experimental setup utilized the Parr reactor series 4650, a 500 ml batch reactor manufactured by Parr Instruments (Parr Instr., ILL, USA). The experimental matrix is presented bellow.



Sample type	Temperature, °C	Initial pressure, bar	40% H_2O_2 addition, wt.%	Process time, min	Waste-Liquid ratio, wt.%
MSW	200, 250, 300	30	30, 45, 60	45	3, 5, 7

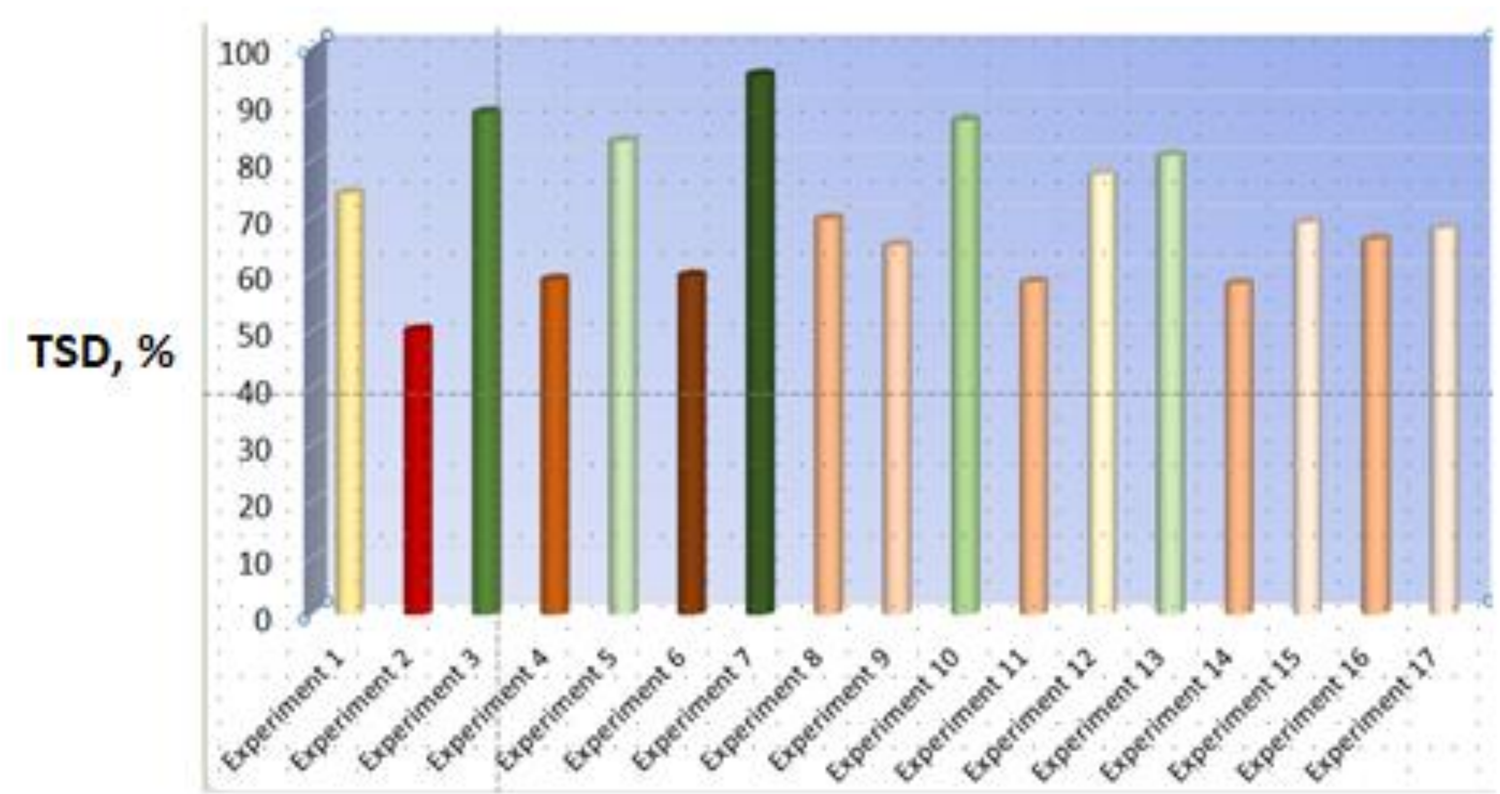
To evaluate the degree of degradation of organic matrices during the process, we performed the calculation of total solid degradation (TSD). In this context, the variable m_f represents the mass of the solid product after drying, while m_i denotes the initial mass of the tested waste material.

$$TSD = \frac{m_i - m_f}{m_{i\cdot}} \cdot 100\%$$

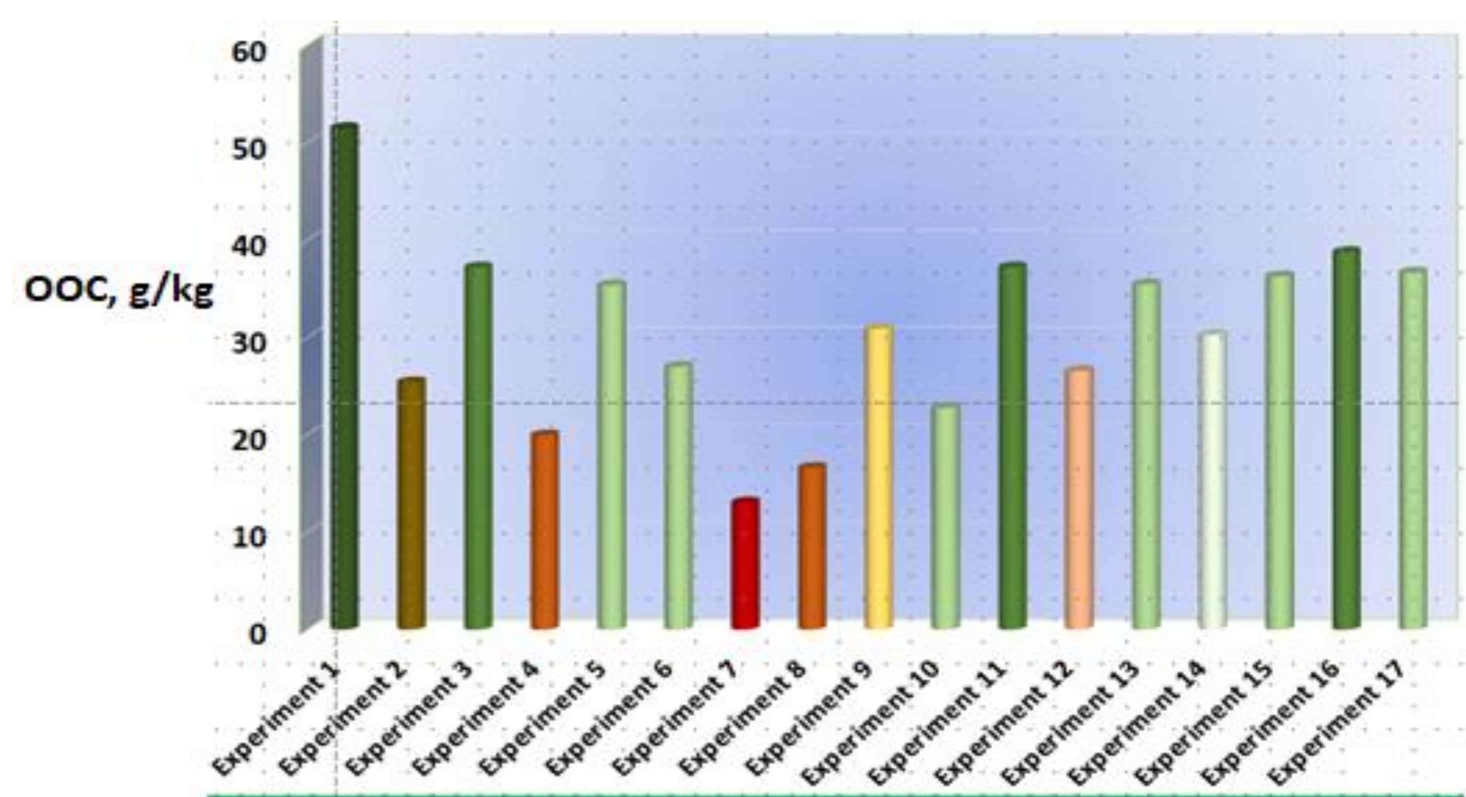
The liquid products obtained through oxidative liquefaction undergo analysis using Gas Chromatography with Flame Ionization Detection (GC-FID).. Calibration curves were constructed to facilitate the quantitative measurement of specific oxygenated organic compounds (OOCs).

RESULTS

Total solid degradation TSD results



Oxygenated organic compounds (OOC) concentration result



CONCLUSIONS

The thorough investigation of the oxidative liquefaction of MSW, supplemented by ultimate and proximate analysis, discloses unique features favorable to waste valorization. The TSR results highlight MSW's improved capacity for reduction, and the OOC yields confirm MSW's favorable carbon profile for producing oxygenated compounds. Ideal reaction conditions, which prioritize lower temperatures, lower oxidant concentrations, and smaller waste-to-liquid ratios, point to a more complex strategy for optimizing sustainability and efficiency in waste treatment operations, with various waste kinds requiring different approaches