Public report TSE Haalbaarheidsstudie “Licht in de duisternis met DUVRS”

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Recycling More: Harnessing Deep-UV Raman for Efficient Black Plastic Recycling

Deep-UV (DUV) Raman spectroscopy is set to revolutionise plastic recycling, offering a powerful solution for sorting plastics, especially black plastics that have long posed a challenge for conventional methods. This cutting-edge technology not only enhances the efficiency of recycling processes but also contributes significantly to reducing carbon emissions, promoting a more sustainable and circular economy. This document presents the key findings of our feasibility study, focusing on the technical feasibility, integration possibilities, software requirements, economic viability, and the broad environmental and market benefits of adopting DUV Raman technology.

Unmatched Efficiency in Plastic Sorting

DUV Raman spectroscopy has proven to be a highly effective solution for identifying black plastics, which are notoriously difficult to detect with existing technologies like near-infrared (NIR) spectroscopy. Notably, black plastics constitute approximately 15% of all plastic recyclables, yet they are often not recycled due to detection challenges (source: [beyondplastics.org](https://www.beyondplastics.org/fact-sheets/black-plastic?utm_source=chatgpt.com)). By using a specialised excitation wavelength below 250 nm, DUV Raman overcomes fluorescence interference, making it possible to detect plastics with exceptional accuracy, even in the presence of additives. This advanced sorting capability translates into tangible environmental benefits, allowing for higher recycling rates and reducing the need for virgin plastic production.

Key technical challenges, such as ensuring efficient light collection and real-time signal acquisition, have been addressed through the development of specialised high-power laser systems and precision optics. The technology has already demonstrated its potential for large-scale industrial use, showing great promise for improving recycling rates in sectors like electronic and automotive waste, which are currently less accessible for recycling.

Real-Time Scanning for Industrial Applications

A major advancement offered by DUV Raman is its ability to integrate into existing recycling systems as an in-line scanning add-on, enabling real-time sorting on conveyor belts. The feasibility study evaluated different configurations, ensuring that this technology can be adapted to varying plastic sizes and shapes, thus boosting overall productivity. Although the initial setup involves significant costs, the improvements in sorting efficiency and the resulting reduction in plastic waste make this investment worthwhile for large-scale industrial adoption.

Alternative Applications: Off-Line Flakes Identification and Microplastics Analysis

Beyond real-time sorting applications, DUV Raman technology also shows great potential for off-line plastic flake identification and microplastic analysis. In offline setups, this technology can be used to identify plastic flakes in batch processes, providing detailed composition information that enhances the quality of the recycled material. Additionally, DUV Raman can be applied to the identification and characterisation of microplastics, which are increasingly recognised as a major environmental pollutant. By accurately identifying microplastics down to very small particle sizes, this technology can contribute to better monitoring and reduction efforts, aligning with global environmental protection goals.

Intelligent Software and Data-Driven Recycling

The success of DUV Raman technology also hinges on its sophisticated software infrastructure. A real-time classifier that processes data swiftly, coupled with cloud integration, ensures seamless synchronisation of the entire sorting process—right from laser detection to actuator operation. Another cornerstone of this system is the plastic identification database, specifically tailored for DUV Raman spectra. This dynamic, cloud-connected database will be continually updated with experimental and industry data, ensuring accuracy and adaptability to evolving recycling needs. Such advanced data infrastructure is key to maximising efficiency and ensuring the highest quality in sorted recyclates.

Economic Benefits and Sustainability

Investing in DUV Raman technology is not only an environmentally responsible decision but also one that is economically sound. By efficiently sorting black plastics and other hard-to-recycle materials, this technology shows great promise for high-value recycling niches such as electronic waste and automotive components. These niches have traditionally been less accessible for recycling due to the technical challenges involved. Government subsidies and upcoming European Union regulations that encourage recycling provide an additional boost to market adoption (source: [consilium.europa.eu](https://www.consilium.europa.eu/en/press/press-releases/2024/03/04/packaging-council-and-parliament-strike-a-deal-to-make-packaging-more-sustainable-and-reduce-packaging-waste-in-the-eu/?utm_source=chatgpt.com)).

Moreover, various economic opportunities emerge from adopting this technology, including revenue from licensing, leasing sorting equipment, selling additional modalities, and providing analysis and feedback on on-site results using a company-based database. These revenue models, combined with government incentives such as the increasing governmental support in both the United States and Europe for recycling and circular economy initiatives. In the European Union, support includes Extended Producer Responsibility (EPR) schemes, EU funding programs such as Horizon Europe, and specific national subsidies aimed at reducing the operational costs of recyclers and making recycling economically attractive. For example, certain countries offer financial incentives based on the volume of recycled material, providing recyclers with direct benefits per ton of plastic processed (sources: [epa.gov], [circulareconomy.europa.eu], [egen.green], [circulareconomy.europa.eu], [egen.green]), make the financial prospects of this innovation even more compelling.

Driving CO_2 Reduction and Sustainability Goals

An important aspect of DUV Raman technology is its ability to significantly reduce carbon emissions, which makes this project highly attractive for sustainability-focused stakeholders. By increasing recycling rates and decreasing the need for virgin plastic production, this technology plays a crucial role in cutting CO_2 emissions. According to industry estimates, recycling just one ton of plastic can save approximately 5,774 kWh of energy compared to producing new plastic from raw materials (source: [climateofourfuture.org](https://www.climateofourfuture.org/how-much-energy-does-it-take-to-recycle-one-ton-of-plastic-and-what-are-the-benefits/?utm_source=chatgpt.com)). This energy saving directly translates to a significant reduction in emissions, helping industries meet their sustainability targets while also conserving valuable natural resources.

Addressing Non-Technological Barriers

The adoption of DUV Raman technology is also influenced by non-technological factors such as regulatory support, market dynamics, and industry acceptance. The current regulatory landscape in the European Union, which pushes for greater recycling rates and the recyclability of all packaging by 2030, provides a favourable environment for the adoption of advanced sorting technologies. Meanwhile, market dynamics, such as fluctuating virgin plastic prices driven by changing oil prices, impact the profitability of recycling operations. By enhancing the quality and precision of recycled plastics, DUV Raman technology helps mitigate these fluctuations and make recycling a more economically attractive option.

Industry partnerships and consumer awareness are equally important. Demonstrating the effectiveness of DUV Raman through pilot projects and working closely with established recycling companies can help build trust and accelerate adoption. Raising public awareness of the benefits of high-quality recycled materials can also foster demand, driving the entire industry towards more sustainable practices.

Conclusion

Deep-UV Raman spectroscopy offers an innovative, powerful tool to tackle some of the most pressing challenges in plastic recycling today, especially for black plastics, which have long been difficult to detect and recycle with conventional methods. It has the potential to drastically reduce carbon emissions, improve recycling efficiency, and open up new economic opportunities within traditionally challenging recycling streams. By investing in this technology, we not only pave the way for more sustainable waste management practices but also significantly contribute to the global effort to achieve a circular economy. With strong regulatory support, promising financial incentives, and a clear pathway to market implementation, DUV Raman technology is poised to become a transformative force in the recycling industry.