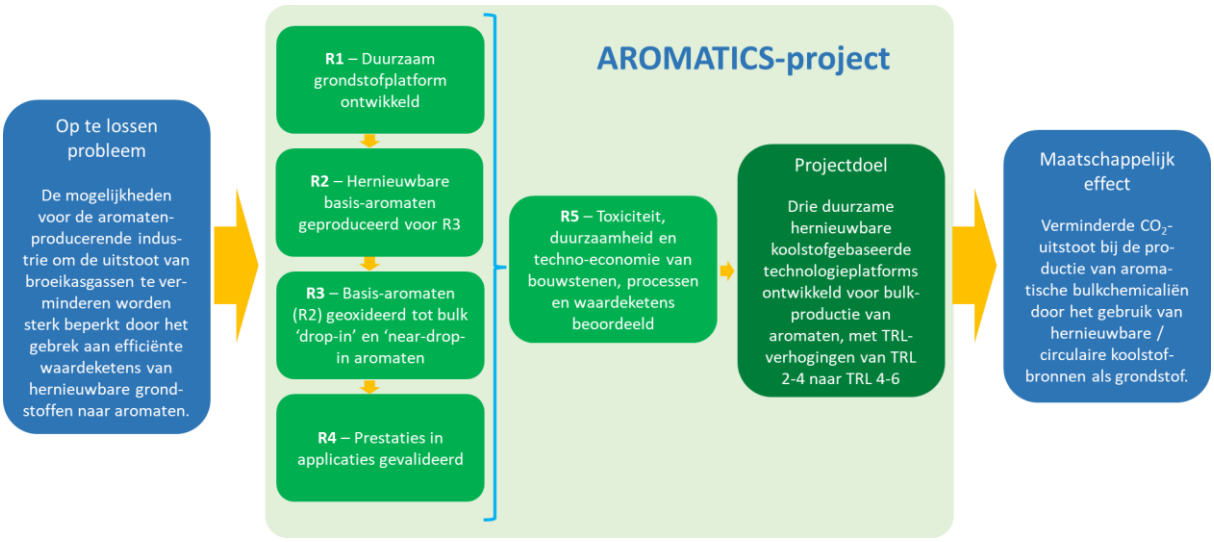
Progress report project year 2 (16 June 2024 – 16 June 2025)

Project title	:	Aromatic Renewables as an Opportunity for MATerials with Improved Circularity and Sustainability (AROMATICS)
Project number	:	MOOI 422008
Date	:	July 12, 2025
Publishing Partner and Author	:	Wageningen Food & Biobased Research, Dr. Shanmugam Thiyagarajan



Summary of the principles and objectives of the project and the collaborating parties

A large part of the products of the chemical industry is based on the building blocks benzene, toluene and xylene ('BTX') predominantly obtained from petroleum. BTX and its derivatives are indispensable for e.g. the stability, resistance to chemicals and weathering, hardness, abrasion resistance and strength of synthetic materials. There are no efficient routes yet to produce these *aromatics* from biomass feedstocks. This is a major limitation of the chemical industry's ability to reduce greenhouse gas emissions and reduce its carbon footprint. The partners in the AROMATICS project, therefore, want to develop three different technological platforms for the conversion of biomass into aromatics. The focus is on making chemical building blocks that are used in large volumes for the production of polymers for plastics and coatings, such as terephthalic acid, isophthalic acid and phthalic anhydride (for binder and in coatings). In addition, the consortium is focusing on developing new pathways to building blocks that are very similar to these aromatics with additionality functionality that may offer different and enhanced properties to the end products due to their slightly different structure. Furthermore, some of the

intermediate chemicals will be evaluated as fragrances in, for example, personal care products or detergents. The sustainability, safety, and techno-economic feasibility of all developed routes will be compared with current commercial processes.

Description of the activities carried out, the results achieved per milestone, the bottlenecks and the perspective for application

The work within AROMATICS is divided into different result sections. The successive results represent the main links in the value chain.

Result 1: Sustainable feedstock platform

Within this result package, processes are optimized to obtain the carbohydrate-based precursors for the three technology platforms in suitable quantities and a sufficiently high purity and to make them available to other project partners. These are side streams and by-products such as lignin, humins, but also sugar-based furans. The first samples were delivered by project partner Avantium to participants TNO and BioBTX. TNO has provided a proof of concept for the conversion of furfural (one of Avantium's by-products) into an intermediate that is needed in one of the three platforms for further conversion to aromatics. Although still in the development stage, BioBTX has demonstrated the potential to convert byproducts into the BioBTX fraction.

Result 2: Access to renewable aromatic core building blocks

In this result package, the focus is on developing pathways to bio-based aromatic chemicals, such as BioBTX and intermediate benzaldehydes that will be converted into terephthalic acid (PTA) and phthalic acid (PA). In addition to starting materials for the intended phthalates, the latter are also interesting as fragrances. Although still in the development stage with respect to improve the conversion and yield, BioBTX has demonstrated the potential to convert byproducts (lignin and humins) from Avantium into the BioBTX fraction. Wageningen Research has successfully synthesized *para*-methyl benzaldehyde (*p*-MBA) by employing homogeneous catalysts in the 'C4 platform', and is now working on the investigation of heterogeneous catalysts system. Thus, synthesized *p*-MBA will be tested in the application such as fragrances by the industrial partners Unilever and IFF. Wageningen Research has also made a proto-type sample similar to phthalic anhydride (PA) but with additional functionalities, which will be evaluated in the applications where PA is used. Relement has made progress in the process of making another aromatic, which is also very similar to phthalic anhydride, from furans made from carbohydrates. This involves improvements in scale, energy reduction and increasing yield. TNO has provided a proof of concept in the conversion of furans from Avantium to benzaldehydes.

Result 3: Access to renewable oxo-functionalized aromatic building blocks

Here, the oxidation processes are developed to produce the targeted phthalate isomers (phthalic anhydride, *iso*phthalicacid, terephthalic acid, and phthalic anhydride-like substances). The continuous oxidation infrastructure has been successfully realized. The unit is currently being fabricated by the supplier to meet the specified requirements. It is expected to be delivered and operational for trial testing in Q3 2026.

Result 4: Validation of the renewable oxo-functionalized building blocks in applications

Several samples have been delivered to the industrial partners for validation through application testing. Allnex has tested new biobased building blocks (aromatic chemicals) that mimic phthalic anhydride in resin synthesis under benchmark conditions. The performance of the new resins will be investigated in the upcoming period. In collaboration with the consortium, new plans were also discussed to explore the potential of these biobased aromatic chemicals in other applications where PA is primarily used.

Result 5: Dedicated toolbox for toxicity, techno-economic and sustainability assessment of renewable aromatics value chains

To monitor whether the routes developed in AROMATICS are sustainable, safe and techno-economically feasible, they are tested on these aspects by Utrecht University (UU), BioDetection Systems (BDS) and TransitionHERO

(TH) respectively. UU has successfully completed a case study on the cradle-to-gate life cycle assessment (LCA) of the (intermediate) products derived from Avantium's DAWN and YUKON process. Efforts are already underway to gather the necessary data for a new case study focusing on the (intermediate) chemicals from BioBTX, RELEMENT, and TNO, in addition to the data generated by TH. The potential samples for which the toxicity profiles were not known will be identified in every result section in the coming period, BDS will investigate the toxicity of these substances, to validate the sustainable and ecofriendly production of aromatic chemicals from biomass feedstocks.

Result 6: Stakeholder engagement and knowledge dissemination

UU, in collaboration with Avantium, has finalized and submitted the manuscript detailing the findings of the LCA of furanics derived from residual woody biomass as feedstocks.

Contribution of the project to the objectives of the scheme

By developing the three platform technologies to make aromatics from biomass, the AROMATICS project contributes to the objectives of *Mission C - Industry* to achieve an economically feasible transition to a clean, energy-efficient, sustainable and safe industry. The intended innovations within AROMATICS fall within *Innovation Theme 2: Production of sustainable and circular bulk and platform chemicals*, in which the development of sustainable processes and value chains for the production of aromatics is specifically mentioned. The raw materials that will be used in the project correspond to the raw materials mentioned in *subtheme 2a: Circular or bio-based raw materials for bulk and platform chemicals*; they include carbon-containing waste streams and bio-based raw materials.

Spin-off within and outside the sector

The developments have not yet developed far enough for spin-off in this second year of research.

Public publications about the project and where to find or obtain them

Projectinformatie op de website van de Topsector Energie:
https://projecten.topsectorenergie.nl/projecten/aromatic-renewables-as-an-opportunity-for-materials-with-improved-circularity-and-sustainability-aromatics-37426
For the press release, see https://www.biorizon.eu/news/dutch-public-private-sponsored-project-aromatics-kicks-off.
The presentations at conferences and events are not publicly available (only accessible to participants).

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The AROMATICS project was carried out with a Top Sector Energy subsidy from the Ministry of Economic Affairs and Climate, carried out by the Netherlands Enterprise Agency. The specific subsidy for this project concerns the MOOI subsidy round 2020.