Carbon dioxide (CO_2) is the leading greenhouse gas emitted by humans, and it causes numerous problems in the environment such as heatwaves, storms, floods, droughts, wildfires and destruction of vital ecosystems. It also negatively affects humans through food insecurity, health issues, property damage and displacement (Nations, 2012).

Transportation vehicles, such as cars and buses, are a major contributor to the high levels of CO_2 in the atmosphere. Gas-powered vehicles release CO_2 as an unavoidable byproduct of combustion. Due to CO_2 being chemically stable, current exhaust systems, including catalytic converters, do not eliminate it (Hamilton et al., 2023). This means that even cars equipped with modern emissions control systems continue to emit significant quantities of CO_2 every time they operate.

Scientific assessments have shown that atmospheric CO_2 concentrations continue to climb, accelerating warming and increasing the severity of climate-related disasters (IPCC, 2021). While electric vehicles, hydrogen-powered systems, and renewable energy technologies are growing rapidly, internal combustion engines remain widespread, and millions of gas-powered vehicles are expected to remain on the road for decades. This creates a pressing need for transitional technologies that can mitigate emissions from existing vehicles.

Carbon capture technologies have traditionally focused on industrial smokestacks or large-scale direct air capture (DAC) systems. These systems often require significant infrastructure, energy inputs, and investment (Alizadeh et al., 2024). However, emerging research has expanded into mobile carbon capture designs, systems built to operate on moving platforms such as long-haul trucks and heavy-duty machinery (Hamilton et al., 2023; Kim, 2024). These advancements demonstrate growing interest in distributed, decentralized forms of carbon capture that do not rely on stationary facilities.

Chemical absorption, or chemical scrubbing, remains one of the most effective CO_2 mitigation strategies for small-scale systems. Hydroxides (any chemical containing OH) are particularly notable due to their rapid reaction with CO_2, decent absorption capacity and good affordability (Stern et al., 2012; House et al., 2011). The reaction converts CO_2 into carbonate (element + CO_3), a stable solid that remains safely inside the filter until disposal. This makes hydroxides a compelling removal medium for an exhaust-mounted device.

By adapting chemical principles into an exhaust-mounted system, this project aims to capture CO_2 at the exact moment it is generated, making it one of the first prototypes to explore individualized carbon capture, for the average consumer, at the source. This project integrates chemistry, engineering and environmental science to create a practical CO_2 filtration device that everyday drivers could eventually use, contributing directly to emissions reduction at the individual level.