Ammonia as a marine fuel: a review of current response tactics.

Abstract

Shipping is crucial to a globalised economy, with over 80% of all goods being transported by sea. Nonetheless, carbon dioxide emissions from shipping account for 3% of global anthropogenic emissions (Deng, 2023). Despite being one of the most efficient freight methods, the emissions from shipping are still exceedingly high due to the heavy reliance on fossil fuels (IEA, 2023). To meet decarbonisation goals the shipping industry is seeking low-carbon alternative fuels.

There are numerous potential fuel sources which are currently being developed as low-carbon alternatives for fossil fuels. Ammonia (NH_3) is possibly the most viable of all the currently researched options as it contains no carbon, allowing for completely carbon free marine propulsion. It can also be used to efficiently transport hydrogen as it has almost double the energy density of liquid hydrogen (Solobeivhik, 2017). Alongside this, ammonia is the second most produced chemical in the world (Brightling, 2018) and has significant infrastructure in place for its manufacture and transportation. Reducing the economic burden of the transition to new fuels.

Despite its numerous benefits, ammonia does present challenges that need to be addressed to ensure it can be utilised with confidence, from an environmental and safety perspective. These relate to the carbon dependency of its production and its behaviour following a release.

The 'carbon free' title of ammonia engines does however have a caveat. The Haber-Bosch process, which is used to produce almost all ammonia, is very energy intensive and is responsible for 1.8% of global carbon dioxide emissions (The Royal Society, 2020). The green production of ammonia is possible with the implementation of renewable energy sources in the Haber-Bosch process and would make ammonia a completely carbon free fuel, from source to engine.

Releases of ammonia can cause significant harm to the human and natural environment. This is especially key for responders who require sufficient training and suitable PPE. The dangers are best observed from a release in Dakar, Senegal, where 22m.t. of pressurised ammonia caused 129 fatalities and 1,150 injuries (Bouet, 2005). Ammonia can also have severe effects on the marine environment with tissue damage, asphyxia and behavioural changes in both fish and invertebrates (Bobermin, 2013). Impacted fauna have limited rehabilitation options with most needing to be euthanised.

Response measures and research into ammonia spill response in the marine environment are limited due to the lack of significant spills. This will likely change with an increase in ammonia production and transportation as it is use as a marine fuel. Currently the only viable method of responding to an ammonia spill is to use water curtains to remove ammonia in the atmosphere. This is currently in use to disperse LNG vapour clouds onboard vessels (Rana, 2010), however, ammonia hydroxide which is produced when ammonia dissolves in water is a strong alkaline and will damage infrastructure it contacts. Due to the limited response options, air quality monitoring and modelling will be key in a response to an ammonia release. With vulnerable resources prioritised for protection and personnel evacuated.