Go to work on a Christmas card

December 23 2011

If all the UK's discarded wrapping paper and Christmas cards were collected and fermented, they could make enough biofuel to run a double-decker bus to the moon and back more than 20 times, according to the researchers behind a new scientific study.

The study, by scientists at Imperial College London, demonstrates that industrial quantities of waste paper could be turned into high grade biofuel, to power motor vehicles, by fermenting the paper using microorganisms. The researchers hope that biofuels made from waste paper could ultimately provide one alternative to fossil fuels like diesel and petrol, in turn reducing the impact of fossil fuels on the environment.

According to some estimates 1.5 billion cards and 83 square kilometres of wrapping paper are thrown away by UK residents over the Christmas period. They currently go to landfill or are recycled in local schemes. This amount of paper could provide 5-12 million litres of biofuel, say the researchers, enough to run a bus for up to 18 million km.

"If one card is assumed to weigh 20g and one square metre of wrapping paper is 10g, then around 38,300 tonnes of extra paper waste will be generated at Christmas time," said study author Dr Richard Murphy from the Department of Life Sciences at Imperial College London. "Our research shows that it would be feasible to build waste paper-to-biofuel processing plants that give energy back as transport fuel."

Co-author and PhD student Lei Wang, also from Imperial's Department

of Life Sciences, said: "The fermentation process could even cope with festive paper and card which has been 'contaminated' with the likes of glitter and sellotape. The cellulose molecules in sellotape would be broken down into glucose sugars and then fermented into ethanol fuel, just like the paper itself. Insoluble items like glitter are easy to filter out as part of the process."

Dr Murphy added: "People should not stop recycling their discarded paper and Christmas cards because at the moment there is no better solution. However, if this technology can be developed further, waste paper might ultimately provide a great, environmentally friendly alternative to fossil fuels. There's more work to do to assess the effectiveness and benefits of the technology, but we think it has significant potential."

In the study, published this month in the Royal Society of Chemistry journal Energy and Environmental Science, the researchers describe how they fermented different types of paper and cardboard in the laboratory to assess how chemically and economically feasible it is to turn them into ethanol fuel. They found that it is not only possible in laboratory experiments but should be economically viable on a large scale as well.

Across the year, around 60 per cent of the UK's waste paper is collected for recycling or other waste management schemes, which equates to around 8 million tonnes. The scientists say that using a well-tested fermentation method and a novel cocktail of efficient and cheap chemical enzymes, their system could be scaled up to the size of existing industrial processing plants and be used to convert 2000 tonnes of waste paper per day into biofuels.

There is already an urgent need for councils to prevent reusable materials like cardboard and paper being sent to landfill sites, saving money and avoiding unnecessary waste, a message echoed by the Mayor

of London Boris Johnson in a speech about Recycle for London's Nice Save campaign this week. This new research shows that in addition to recycling, waste materials can be used to generate energy, and some of that can be as valuable vehicle fuel.

High grade ethanol, such as that made in this study, can be (and already is) blended with fossil-based petrol to make a fuel with lower greenhouse gas balance than conventional petrol for cars and vans, and can also be used to power large diesel vehicles like buses and trucks, if modifications are made to their engines. This approach is already used in Brazil, the USA and the EU, among other regions, where ethanol biofuels are being made from sugar cane, grain and other crops. Most of the UK's biofuel is currently imported from abroad.

The authors of this study are now analysing the environmental performance of bioethanol made from waste paper using life cycle assessment (LCA) and comparing it with the conventional transport fuel petrol. LCA is an environmental management tool that evaluates the 'cradle-to-grave' effects of a product for its influence on a range of environmental impact categories, including its ability to contribute to climate change or soil acidification or to cause algal blooms in fresh water.

More information: Wang L, Sharifzadeh M, Templer R and Murphy RJ "Technology performance and economic feasibility of bioethanol production from various waste papers" is published in *Energy and Environmental Science* DOI: 10.1039/C2EE02935A

Provided by Imperial College London

Citation: Go to work on a Christmas card (2011, December 23) retrieved 19 September 2024

from https://phys.org/news/2011-12-christmas-card.html

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