Snooker, not pinball

In 2011, Andrzej Stankiewicz, professor of process intensification (3mE faculty), received a grant of 2.3 million euros from the European Research Council to conduct research into the improvement of chemical reactors at molecular level. Last September, Stankiewicz’s ‘Perfect Reactors Lab’ opened its doors. One type of microreactor is already known: a glass plate through which molecules can flow through micro- or nanochannels. But how can one perfect a microreactor and how does it work? For more information see: www.pe.tudelft.nl/Chairs/IIRS

A pinball machine with efficient collisions

The current practice in the chemical industry is to mix substances together in a large reactor vessel (with a capacity of e.g. 10 m³). During mixing, the molecules collide randomly much in the same way as balls do in a pinball machine. The walls of the reactor are heated to increase the number of collisions and to give the molecules the required activation energy. A disadvantage of this method is that large temperature gradients arise. Some molecules become too hot and form undesirable products, while other molecules are not hot enough and do not react. The macroscopic regulation of the process means that only a small number of the collisions actually lead to the desired reaction and only part of the substances being mixed actually react to create the final product.

Spectacular improvement of reactor yield

Collisions between chlorine atoms and methane molecules can result in the production of hydrogen chloride. A laser beam can be used to add energy to the H atoms in the methane molecule. This stretches the bonds in the methane molecule and increases the ‘target area’ so that even non-frontal collisions become effective. Experiments in the United States have shown that using a laser can increase the reaction rate by a factor of 100.

Activating molecules using laser light

The desired reaction only occurs if molecules have a particular energy when they collide. Laser light can be used to add a specific amount of energy to the molecules to achieve the required activation energy. The additional energy causes the atoms to become excited more quickly, weakening the bonds between them and enabling reactions to occur more frequently. The Perfect Reactors Team is going to investigate the effects of laser light on reactions.

Electrical power from waste

A very practical application of research into the activation of molecules is the development of a simple process for converting human excrement into fuels. A working prototype is expected to be ready within a year. In developing countries, the new toilet system will provide energy to people and improve hygiene at the same time. The project is being funded by the Bill and Melinda Gates Foundation. The envisaged system will fit into a standard shipping container.

Fuel cell (SOFC)

The hydrogen gas released during the process can be used in a fuel cell. The reaction of hydrogen and air (oxygen) to produce water results in electrons being released that can be used to drive an electric motor.

Activating molecules using microwaves

A lot of heat is required to convert the hydrocarbons in waste products (using oxidation) to syngas fuel (a mixture of hydrogen and carbon monoxide). This chemical process, gasification, only occurs at high temperatures (1000 to 2000 °C). These high temperatures can be achieved by heating a stream of gas enough for it to become a plasma (a hot cloud in which some of the atoms break down into atoms and electrons). Microwaves can be used to achieve this very local heating.

Illustration and text: Eric Verduyt

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