Cracking of hydrocarbons

The students learn the cracking of hydrocarbons by using a model experiment.

Chemistry	Organic chemistry	Hydrocarbons
Chemistry	Industrial Chemistry	Petrochemistry

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

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General information

Application

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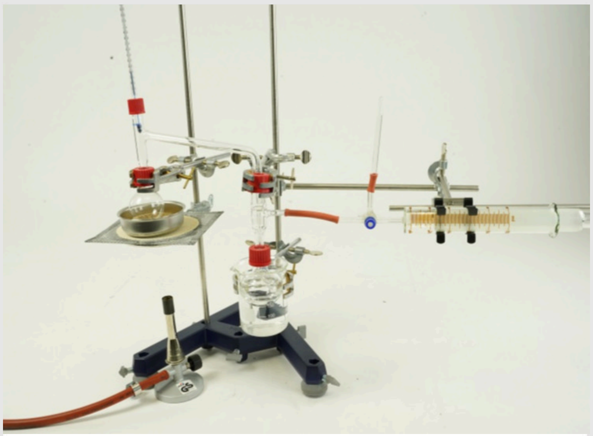

Experimental setup

Under the influence of energy, e.g. heat, light, and electric discharge, all chemical compounds can be broken down into smaller fractions. The presence of a catalyst lowers the activation energy of this cracking reaction so that the decomposition products are formed already at lower temperatures. Saturated carbohydrates are then transformed into smaller saturated and unsaturated molecules.

In this experiment, the students investigate the cracking of hydrocarbons by using a model experiment.

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Other information (1/2)

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Prior knowledge

The Students should already the background of cracking of hydrocarbons. Also, they should be familiar with the catalytic principle.

Scientific principle

Under the influence of energy, e.g. heat, light, and electric discharge, all chemical compounds can be broken down into smaller fractions.

Saturated carbohydrates are then transformed into smaller saturated and unsaturated molecules.Cycloalkanes are dehydrated to aromatic compounds, straight-chain molecules to branched-chain molecules, and branched-chain molecules to cyclic molecules.

Other information (2/2)

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Learning objective

The students learn the cracking of hydrocarbons by using a model experiment.

Tasks

The students investigate the cracking of hydrocarbons using a model experiment

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Safety instructions (1/2)

Experiments involving bromine must be performed under an exhaust hood.

Bromine vapors irritate the mucous membranes and cause inflammation. Liquid bromine burns the skin.

Bromine must be kept under lock and key. Wear protective gloves when transferring bromine into another vessel.

Concentrated acids are highly caustic. They burn the skin and destroy textile fabrics. For diluting, first add the water, then the acid (protective glasses, laboratory coat, gloves).

For the H- and P-phrases please refer to the corresponding safety data sheets.

The general instructions for safe experimentation in science education apply to this experiment.

Safety instructions (2/2)

Dichloromethane (methylene chloride) is a colourless, sparingly water-soluble liquid that decomposes in naked flames and hot surfaces (≥ 120°C) while forming irritant, corrosive substances. Degreasing of the skin. Increases the carbon monoxide level in the blood if ingested in small concentrations.

For the H- and P-phrases please refer to the corresponding safety data sheets.

The general instructions for safe experimentation in science education apply to this experiment.

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Theory

Under the influence of energy, e.g. heat, light, and electric discharge, all chemical compounds can be broken down into smaller fractions. The reaction can continue up to the elements themselves. In general, low-volatile crude oil components are disintegrated as of approximately 400 °C.

The presence of a catalyst lowers the activation energy of this cracking reaction so that the decomposition products are formed already at lower temperatures. Saturated carbohydrates are then transformed into smaller saturated and unsaturated molecules.

Cycloalkanes are dehydrated to aromatic compounds, straight-chain molecules to branched-chain molecules, and branched-chain molecules to cyclic molecules.

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Equipment

Position	Material	Item No.	Quantity
1	Support base DEMO	02007-55	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Right angle boss-head clamp	37697-00	5
5	Universal clamp	37715-01	3
6	Gas-syringe holder with stop	02058-00	1
7	Ring with boss head, i. d. = 10 cm	37701-01	1
8	Iron basin, d 100 mm	33201-00	1
9	Round-bottom flask, 50 ml	MAU-27220001	1
10	Round bottom flask, 100ml, GL 25/12	35841-15	1
11	Distilling bridge GL18/8	35902-15	1
12	Vacuum adaptor, straight, GL25/12	MAU-27228500	1
13	Gas syringe, 100 ml, with 3-way cock	02617-00	1
14	Glass tubes,straight with tip, 10	36701-62	1
15	Lab thermometer,w.stem,-10..+250C	38061-01	1
16	Beaker, Borosilicate, tall form, 250 ml	46027-00	1
17	Porcelain dish, 75ml, d = 80 mm	32516-00	1
18	Test tube rack for 12 tubes, holes d= 22 mm, wood	37686-10	1
19	Test tube, 160 x 16 mm, 100 pcs	37656-10	1
20	Rubber stopper,d=18/14mm,w/o hole	39254-00	1
21	Teclu burner, DIN, natural gas	32171-05	1
22	Safety gas tubing, DVGW, sold by metre	39281-10	1
23	Lighter f.natural/liquified gases	38874-00	1
24	Hose clip f.12-20 diameter tube	40995-00	2
25	Rubber tubing, i.d. 6 mm	39282-00	1
26	Bromine filler w. rubber cap	45100-00	1
27	Pasteur pipettes, 250 pcs	36590-00	1
28	Rubber caps, 10 pcs	39275-03	1
29	Spoon, special steel	33398-00	1
30	Wash bottle, plastic, 500 ml	33931-00	1
31	Rubber gloves, size L (9), one pair	39324-00	1
32	Wood splints, package of 100	39126-10	1
33	Glass wool 10 g	31773-03	1
34	Bead catalyst, 500 g	31761-50	1
35	Paraffin, 500 gr	30179-50	1
36	Sea sand, purified 1000 g	30220-67	1
37	Bromine-Solution, 250 ml	30046-25	1
38	Water, distilled 5 l	31246-81	1
39	Wire gauze with ceramic, 160 x 160 mm	33287-01	1

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Setup and procedure

Setup

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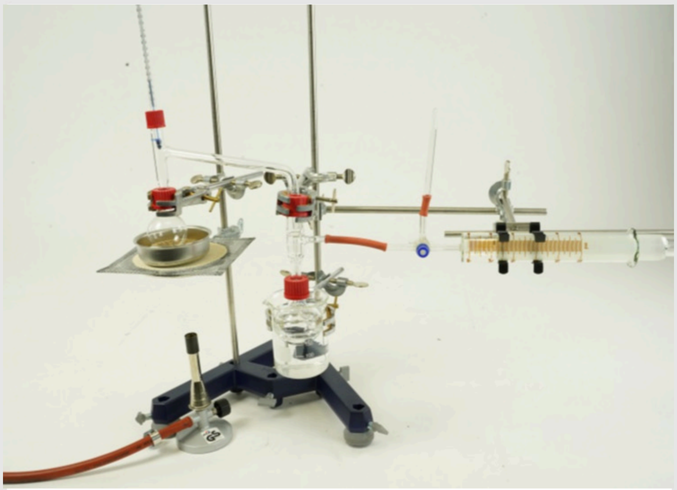
Set up the base with two rods in the base.

Connect the destilling bridge and the round bottom flask and a vaccum

Set the 100 ml round bottom flask up on a sand bath as shown in the figure on the right.

Fill it half full with catalyst beads and then add a few spatula spoons of solid paraffin.

Cool the receiving flask in a beaker with ice water.



Experimental setup

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Procedure (1/2)

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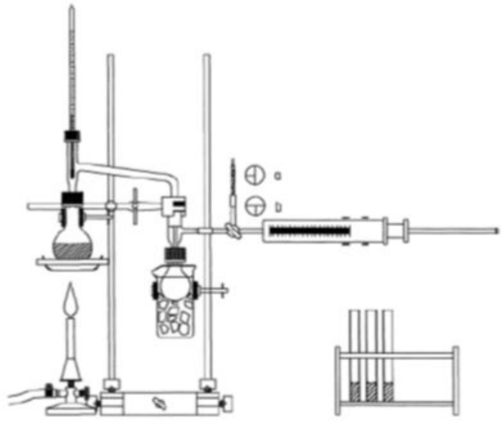
Then, heat the sand bath slowly with the burner.

After the air has been pushed out of the apparatus (position (a) of the stopcock of the syringe),

- open the three-way stopcock towards the gas syringe (position (b)),
- collect 100 ml of gas,
- and seal the syringe again (stopcock back to position (a)).



Stopcock positions

Procedure (2/2)

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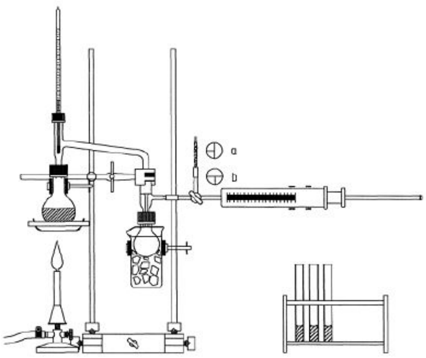

Experiment setup

Continue to heat the reaction mixture for another 10 minutes until a sufficient amount of liquid has collected in the 50 ml round bottom flask.Remove the burner, push some of the gas from the syringe through the glass tube that is filled with quartz glass wool, and ignite it.

Guide the remaining gas into a test tube that is filled with diluted bromine water (see the appendix).

Distribute the content of the 50 ml round bottom flask into a test tube and an evaporating dish.

Add a little bromine water to the sample in the test tube and shake it. Ignite the sample in the evaporating dish with a burning wood splint.

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Evaluation

Evaluation (1/4)

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Result

When the flask is heated, liquid and gaseous cracking products are produced. When they are ignited, they burn with a bright flame, and they discolour the bromine water. During the reaction, the catalyst beads are covered with a carbon deposit. The fogging becomes increasingly weaker until it stops completely, and no further product passes over.

Note

The reaction products can also be examined by way of gas chromatography. Based on the retention times and a comparison with the pure substances, the cracking products can be identified. In most cases, the apparatus can be cleaned simply with benzine. Stubborn, tar-like residues can often be removed with tetrahydrofuran. Collect the dissolved residues for disposal in a vessel for non-halogenated, organic substances.

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Evaluation (2/4)

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What does the presence of a catalyst do?

- ○ The presence of a catalyst lowers the activation energy of this cracking reaction so that the decomposition products are formed already at lower temperatures.
- ○ None of the answers is correct. A catalyst simply heats the whole reaction like a heating plate.
- ○ The presence of a catalyst increases the activation energy of this cracking reaction so that the decomposition products stable until the temperatures increase.

Überprüfen

Evaluation (3/4)

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Mark the correct statements.

- ☐ Under the influence of energy, e.g. heat, light, and electric discharge, all chemical compounds can be broken down into smaller fractions.
- ☐ Bromine vapours irritate the mucous membranes and cause inflammation.
- ☐ Under the influence of energy, e.g. heat, light, and electric discharge, all chemical compounds can be combined into bigger fractions.
- ☐ Experiments involving bromine must be performed under exhaust hood.

Überprüfen

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Evaluation (4/4)

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Summary of the experiment

When the flask is ________, liquid and gaseous cracking products are produced. When they are ________, they burn with a bright flame, and they discolour the ________ water.
During the reaction, the ________ are covered with a carbon deposit. The fogging becomes increasingly weaker until it stops completely and no further product passes over.

- heated
- bromine
- ignited
- catalyst beads

Überprüfen

Folie	Punktzahl/Summe
Folie 15: Function of the Catalyst	0/1
Folie 16: Influcence of energy	0/3
Folie 17: Summary of the experiment	0/4

Gesamtsumme 0/8

Lösungen Wiederholen

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