The Synthesis of Fullerenes – Chemical Soccerballs under low Pressure

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1. Introduction

Spherical carbon molecules, also known as fullerenes have several medical and technical applications and advantages. Because of their shape it is possible to enclose other atoms or molecules inside the fullerenes to isolate them from their surroundings [1]. However, ineffective synthesis methods and high energy expenditure cause high selling prices and low economic value for these chemical soccerballs. This is considered to be reason enough to try and improve the efficiency of one method by varying the pressure and amount of energy required for synthesis.

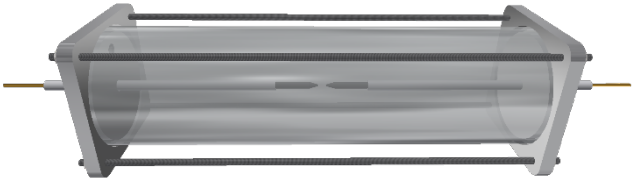

Figure 1: Setup for Fullerene production

2. Experimental Setup

A reaction chamber was built to synthesize fullerenes which contains two graphite rods connected to a welding machine which heats them up to around 4000°C while generating an electric arc between them. Performing this experiment within a steel pipe (shown transparently in the picture above) allows the use of argon gas to prevent any chemical reaction between carbon and other substances as well as the regulation of pressure using a vacuum pump.

At the very end of every experiment the fullerenes are washed out and purified using xylene and ether.

To value the efficiency of each combination – pressure and amount of energy – the relative amount of fullerenes dissolved in xylene is analyzed using the UV light absorbing properties of them.

To measure the exact value of absorption, a photometer consisting of a photodiode and two LEDs (one UV LED to detect the amount of absorption and another blue one to measure the pollution) was built. A micro controller transmits the value generated by the photodiode to a PC via USB where the data is shown in a bar chart.

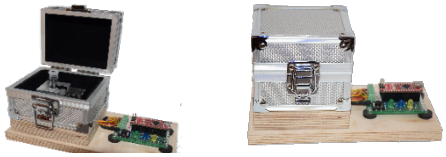

Figure 2: Picture oft the photometer

3. Results

Druck/Energie	1020 mBar	500 mBar	250 mBar	125 mBar	60 mBar	30 mBar
6000 Joule						
12000 Joule						
18000 Joule						
24000 Joule						

Figure 3: Table of results

The table above shows the results of different experiments varying pressure and amount of energy. Green color represents a very high production of fullerenes, red color displays an amount of fullerenes close to zero.

A mass spectrometry test performed at the University of Stuttgart supports these results by showing a peak of molar mass around of 720, which is the molar weight of C60 fullerene [2].

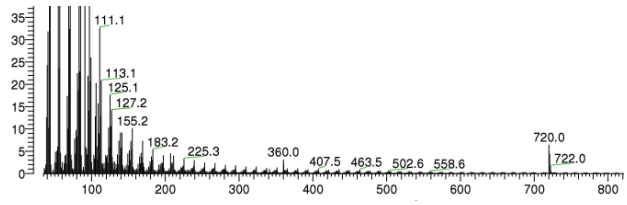

Figure 4: Results of mass spectrometry[X]

4. Conclusion

As shown in figure 3, the most appropriate amount of energy to synthesize fullerene is around 18000 Joule. Previous experiments showed that the proportion between current, voltage and reaction time is not as crucial as the total amount of energy.

An improvement in the production rate can also be achieved by lowering the pressure that prevails during the synthesis. The most appropriate amount of pressure can not be determined at the moment because the vacuum pump reached its limits.

5. References

All graphic material used in this abstract originates from the Jugend-Forscht 2018 project "Fullerene – Chemische Fußbälle, bald mit mehr Inhalt" by Yannik Stark, Leon Stark and Luis Männer.

[1] Solid C60: a new form of carbon, Nature vol. 347 September 27th, 1990

[2] Buckminsterfullerene, Nature vol. 318 November 14th, 1985

[3] Institute of Polymer Chemistry, University of Stuttgart