The Haber - Bosch process

It all started in the late 19th Century and the early 20th Century in Germany, the hub of global scientific developments during this time period. Many lectures were given by top scholars around university campuses emphasizing the importance of nitrates to the German economy. Being a small country land bordered by neighboring Central Europe countries and having only a comparatively smaller sea coast, agriculture was the main focus for development. Since the country did not pose much farmland either, they were forced to use fertilizers and manures that would enable them to continue producing. The wheat harvest depended on imported saltpeter from Chile. It could help produce more food for the rapidly increasing population. The concern in this field was that due to the increased consumption of this saltpeter, the reserves were suspected to be depleted in a few decades or even years if the global population did not cease to grow.

The main component of these nitrates is Nitrogen, and it is present in abundance everywhere in the world. The problem faced is that it is present as Nitrogen gas in the atmosphere, and constitutes almost 70% of all gases present. Many scientists failed in their attempts to liquidize or solidify the Nitrogen for the production of Ammonia, a base component of fertilizers. Everyone figured out that it would require use of very high pressures and temperatures and possibly even the application of a catalyst but none of them, even after continuous attempts, could figure out the right measurements and the right amount of catalyst required producing an effective quantity of the ammonia. It was easy for
them to use immensely high temperatures and pressures but the key to the solution was the percentage of ammonia produced in comparison to the amount of N₂ and H₂ put in.

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N₂ (g) + 3 H₂ (g) ⇌ 2 NH₃ (g) \quad (\Delta H = -92.22 \text{ kJ/mol})
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Even though the equilibrium equation is exothermic, it requires breaking the very strong covalent triple bond in N₂.

In 1908, the Jewish German scientist, Fritz Haber, suggested some raw figures for the production in a small scale machine. The largest chemical company in the world at that time and presently started conducting further research and invested most of its funds in this sector. The competition was too stiff in the chemical dye production business and being a company established in Germany, great pride was involved in every decision. The Tsar’s government predicted an eventual blockade by the American and British naval forces and expected the supply to be cut short. Therefore, a huge sum of money was invested into the research led by Haber.

In 1912, the process of ammonia synthesis was successfully completed; the temperature ranged around 500°Celsius (Approx. 932°Fahrenheit) and 200 atm of pressure was required to be imputed. At first, Osmium (Atomic #76, Os) was used as the main catalyst due to its ability to sustain the extremely high temperature (BP- 5012 °C, MP- 3033 °C). The company immediately purchased all the cesium reserves in the world (Definitely not enough for maximum production and the kind of profits that the company expected for investing in the research). This is what brought Carl Bosh into the picture and why the entire process of nitrogen fixation is generally called the Haber – Bosch Process. He was a very highly educated engineer assisting with another project that the company was investing in. His work ethic inspired many and influenced the company’s decision to promote him to such a task. A year after this, the first ammonia synthesis plant began producing nitrogen fertilizers in Oppau (1913). The annual
output: 7,200 metric tons of ammonia to be processed into 36,000 metric tons of ammonia sulphate. This required hours of work by Bosch and his team. Their initial task was to find a more abundant catalyst that could facilitate the process while ensuring its long term success. They made 100s of small scale models of the plant and began testing every single combination of elements found in nature (Well, at least almost all of them). After months and months of failure... A breakthrough! They were able to find a compound containing small traces of iron that proved to be a better agent than everything they had ever tested, even Osmium. The next task seemed easy at first but the more practical it got, the more unattainable the dream of a prosperous Germany seemed. The engineering needed to implement the Haber process required the use of temperatures and pressures that were difficult to achieve at that time. High Pressure reactors were constructed to sustain >200 atm of pressure.

Next, they had to replicate the small scale model into a huge factory. The risks were enormous; an explosion due to one technical failure could lead to thousands of deaths. The process took several
months but with continuous trial and error, and their relentless ability to not give up finally led to the success they dreamt of.

This process simply shows the impact of chemistry on our lives. At the start of WWI in 1914, Germany was not harnessed by the British blockade and from expert historian analysis, it is predicted that Germany would have lost the war had it not been for Fritz Haber and Karl Bosch. Also, the world’s arable land can sustain only about 4.5 billion people and it is quite surprising that the current generation is quite unaware of one of the greatest discovery and invention that is helping sustain the 6 billion people even today. The irony in the life of Frtiz Haber is beyond surprising, though. He was nominated for the Nobel Prize in Chemistry almost every year until his death but the board refused to acknowledge his accomplishment due to the lives that were lost due to the use of the ammonium sulphate for highly explosive gunpowder by the German forces in WWI. And what is better to award a loyal citizen of Germany? To exile him to Switzerland during the Holocaust under Hitler’s rule...The irony.
Works Cited

