DEPARTMENT OF CHEMICAL ENGINEERING

FINAL YEAR DESIGN 2021

Continuous Nitration of Substituted Aromatics – Final Brief

To: Prof. Klaus Hellgardt and Dr Ali Yetisen

From: Team 8 – New Venture Division of Nitroma

Re: Preliminary design for a multi-purpose, continuous nitration process to manufacture substituted aromatic amines

An aerial photo taken on March 22 shows the site of a factory explosion at a chemical industrial park in Yancheng, Jiangsu province.

Following multiple deadly industrial accidents in chemical plants performing batch nitration, especially the 2019 Xiangshui chemical plant explosion, Chinese authorities are taking actions to strengthen the control and management of nitration manufacturing. Inspections and in-depth risk assessments are expected to be conducted to ensure compliance of the plants with the regulations on dangerous chemicals [1].

Nitration is a key reaction involved in the production of many fertilizer and intermediates synthesis [2]. The nitration of aromatic rings, followed by reduction, is of particular interest for the manufacturing of pharmaceutical compounds and dyes requiring an amino group, which cannot be directly introduced via electrophilic aromatic substitution. Another advantage of nitrated aromatics lies in the easy replacement of the amino group by other functional groups, guaranteeing very versatile intermediates.

In this context, Nitroma wants to seize the opportunity of developing a multi-purpose and continuous liquid phase nitration process for the conversion of substituted aromatics to their respective nitrates and subsequently to their amines. Flow Chemistry will be investigated to design and demonstrate an inherently safer nitration process in the **Nanjing Chemical Industry Park (China)**.

The following details an agreement between Nitroma and Klaus Hellgardt, Edwards Corp plc and Edwards Industries Ltd. made on 21/01/2021 for the design of a continuous process plant for the production of substituted aromatic amines.

1.1 Product Specifications

Table 1: Key product specifications

Products [CAS number]	4-aminobenzaldehyde [556-18-3] 4-aminobenzoic acid [150-13-0] o-toluidine [95-53-4]

Purity	≥ 98% for 4-aminobenzaldehyde and 4-aminobenzoic acid, ≥ 95% for o-toluidine
Flexibility split build-in capacity	4-aminobenzaldehyde: 0-500 tonnes/year 4-aminobenzoic acid: 0-100 tonnes/year o-toluidine: 0-650 tonnes/year

1.2 Manufacturing Specifications

- Nitroma's final design will REACH & be compliant with British safety and environmental standards.
- The nitration of toluene will be continuous, and subsequent steps of the production process will be designed to be continuous wherever practically and economically feasible.
- The process designed by Nitroma will simultaneously produce derivatives of the *para* and *ortho* isomers of nitrotoluene.
- The modular nature of the plant allows Nitroma to efficiently switch between the production of 4-aminobenzaldehyde and 4-aminobenzoic acid, based on the customer demand.

1.3 Market and Economics

- The plant will be located in the Nanjing Chemical Industry Park in China.
- As China is a registered member of the World Trade Organization, Nitroma is able to enter as a Wholly Foreign Owned Enterprise (WFOE), following rules and regulations set out by the new Foreign Investment Law (2020) along with associated Chinese construction laws. WFOEs are regarded as one of the most successful entry modes for engineering firms. Under this entry mode, Nitroma will operate independently, controlling all aspects of the business (including foreign subsidiary operations) and reserves the rights to net profit generated from operations. [3]
- Thanks to its inherently safer continuous nitration process, Nitroma expects to receive subsidies from the Chinese government. The Chinese government specifically gives subsidies to businesses using safer and more automated modes of production. Because the Chinese government subsidises the development of state-of-the art technology—including advanced manufacturing—Nitroma can benefit from lower tax rates and better allowance in company accounting. [4, 5]
- Nitroma aims at capturing, during its first 5 years in operation, the following market shares for its different products, based on the 2020 Chinese market:
    - 4-aminobenzaldehyde: up to 1.5%
    - 4-aminobenzoic acid: up to 3%
    - o-toluidine: up to 0.1%

- The products will mostly be sold to the pharmaceutical, agrochemical and textile industries, which are present locally in China.

Notes

i. Nitroma reserves the right to adjust the production capacity of each product based upon ongoing market research and further negotiation with all parties.
ii. All changes to the agreement will be summarised in future notes.

References

[1] Xinhua Published: 2019/3/25 16:49:21

[2] Booth, Gerald. “Nitro Compounds, Aromatic.” Ullmann’s Encyclopedia of Industrial Chemistry, American Cancer Society, 2000, doi:10.1002/14356007.a17_411.

[3] Ling, Florence Yean Yng, William Ibbs, C and Cuervo, Javier C, 2007, ‘Entry and business strategies used by international architectural, engineering and construction firms in China’, Construction Management and Economics https://www.tandfonline.com/doi/abs/10.1080/01446190500040141

[4] http://jjkfq.nanjing.gov.cn/njjjjskfqglwyh/201910/t20191022_1684395.html

[5] http://www.gaoxinbutie.com/gaoxin/