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Monoethanolamine: Production Plant.

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ABSTRACT

The project will construct a chemical manufacturing plant and produce for sale in Iraq important industrial chemicals for which there is currently no domestic manufacturer. The product range will comprise:-
Monoethanolamine (MEA) - capacity 1000 ton/ year, Diethanolamine (DEA) - capacity 357 ton/ year, Triethanolamine (TEA) - capacity 71.4 ton/ year. The project requires peak funding of $1.9m with approximately half that sum required for the first two years. Manufacture and sale of products will commence in the third year of the project generating annual profits of $799k, $799k and $1.1m in each of the succeeding three years. The project has excellent opportunities to continue to build on profitability and success beyond the initial five-year period. The product range is a key to the manufacture of a broad range, not only of industrial materials, but also consumer goods (cosmetics, photographic materials, soft drinks, etc). In both areas, demands for MEA, DEA and TEA will closely follow the coming economic recovery and regeneration of Iraq.

Keywords: monoethanolamine, diethanolamine, triethanolamine.

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Opportunity

In Iraq there is a shortage of domestically-manufactured industrial chemicals. Ethanolamines (ETA) are used in various industrial applications due to the bifunctional properties of the primary alcohol and primary amine. On the other hand, wastewater containing ETA is difficult to treat due to this bifunctional property. Two typical technologies for ETA removal are electrochemical[1] and biological[2] treatment processes. Ethanolamine (ETA) is widely used for acid or sour gases removal, known as a sweetening process in the NATURAL GAS INDUSTRY[3]

Ethanolamine and other chemical compounds consider very important in our life[1, 4], but also at the same time make a great threat on the environmental, therefore there are different method using for either removing these pollutants such as adsorption processes[5-12], photocatalytic degradation[13-19], etc., or evaluation and controlling the synthesis processes. Monoethanolamine (MEA), diethanolamine (DEA) and triethanolamine (TEA) are but three examples. They have a broad range of applications amongst which the most important are for removing ("scrubbing") hydrogen sulfide and carbon dioxide from petroleum gas streams[20]. Other uses of the bulk materials are in the production of emulsion paints, dispersing agents from agricultural chemicals, light detergents and personal care products. Additionally, they are used as chemical intermediates in manufacturing resins, plasticizers, corrosion inhibitors, rubber chemicals, lubricants and cutting fluids. MEA is an important precursor in the manufacture of carbon dioxide for soft drinks. There are also wider applications in the pharmaceutical sector and as textile softening agents [20, 21].

An estimate of the annual demand for these materials in Iraq is shown in Table 1:

Table 1: Uses of MEA, DEA and TEA

		Tones per year	
Application	**MEA**	**DEA**	**TEA**
Oil and gas industry	950	-----	----
Paints	-----	-----	10
Agricultural chemicals	-----	50	----
Resins and plasticizers	----	-----	46
Cosmetics	50	50	----
Cutting fluids	-----	----	10
Detergents	-----	251	-----
TOTAL	**1000**	**351**	**66**

There is no significant domestic manufacture of MEA, DEA or TEA in Iraq and all materials are therefore imported. The value of these imports in shown in Table 2;

Table 2: Value of the import market for MEA, DEA and TEA

	MEA	**DEA**	**TEA**
Price per tones (US$)	**$2,700**	**$2000**	**$1800**
Tones imported (2005)	**900**	**200**	**100**
TOTAL	**$2,430,000**	**$400,000**	**$180,000**

Solutions

The project is to construct a plant to produce MEA, DEA and TEA. The material will be produced within Iraq where there are opportunities to manufacture materials at prices significantly below imported material. We will exploit the experience in Iraq of local manufacture of industrial precursors and the pool of experienced and skilled chemical industry workers.

Business Model

Products will be manufactured and supplied for sale, packaged according to international standards, in standard 220L barrels. All products will be sold for cash with a 10% deposit being payable with the order. The balance will be paid within 30 days of delivery by the Company or at the time of collection by the customer from the manufacturing plant.

The selling prices will be those shown in Table 4 with a 5% discount offered for customers who opt to collect orders directly from the manufacturing plant.

Technical Advantage

The market for MEA has been tested and demonstrated through expertise in industrial chemical manufacture and sale , In this proposal we will use a more efficient and effective synthesis of MEA, DEA and TEA through the reaction of ethylene oxide with excess ammonia. In all conventional processes, reaction takes place in liquid phase, and the reaction pressure must be sufficiently large to prevent the vaporization of ammonia at the reaction temperature. In our process the ammonia concentration in water will be between 50 and 100%, pressure will be 160 atmospheres and the exothermic reaction will be carried out at temperatures up to 150 C.

The flow sheet for the production of MEA is as shown in the diagram below (Figure 1). This process is described in more detail in the Appendix..

Aqueous ammonia is mixed with a recycled stream of ammonia to achieve a concentration of 30% ammonia in water. This is mixed with ethylene oxide and sent to a plug-flow reactor. Reaction temperature of 50C is maintained in the reactor, and a pressure of 160 atmosphere to avoid the evaporation of ammonia and hence to keep ammonia liquid solution to carry the reaction in liquid phase.

Competition

Competitors to the Company will be:-

- Companies selling imported material, and
- Other domestic manufacturers following our lead.

The major importers of MEA , DEA and TEA into Iraq and the prices of their products are shown in Table 4.

As shown in Fig. 1, we will enter the market with a cost advantage over imported material of not less than 700, 750, and 800 US$ per ton for MEA, DEA and TEA respectively. Although it is possible that there will be some reduction in competitors' prices as a result of our entry into the market, we estimate that this will not be more than 10% and allow us to continue with successful marketing and sales.

Table 3: Selling amount of MEA, DEA, TEA

	Import price US$ per ton	**Selling price US$ per ton**	**Saving US$ per ton**
MEA	2,700	2,000	700
DEA	2,000	1,250	750
TEA	1,800	1,000	800

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Table 4: MEA, DEA and TEA importers

		US$ per ton	
	MEA	**DEA**	**TEA**
Imported price (ex-Iraq)	2,700	2,000	1,800
Target selling price	2,000	1,250	1,000
Competitive advantage	**25%**	**37.5%**	**44%**

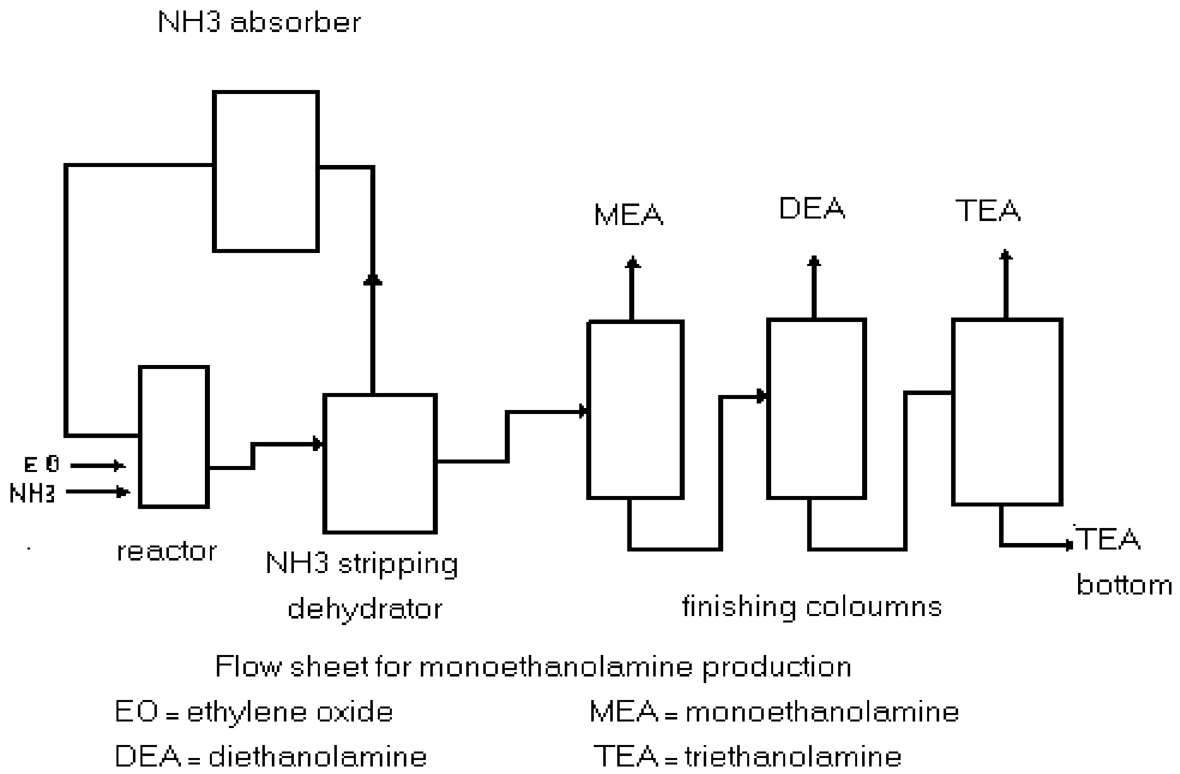


Figure 1: Flow diagram for the synthesis of MEA, DEA and TEA

There are no other domestic manufacturers of MEA, DEA and TEA. However, our early may lead to domestic competitors setting up MEA, DEA and TEA synthesis capability. We estimate that it will take such a competitor not less than 2 years to begin manufacture and sale of significant quantities of competing materials. By that time we will have been selling successfully and developing high market share and strong customer satisfaction.

Sales & Marketing

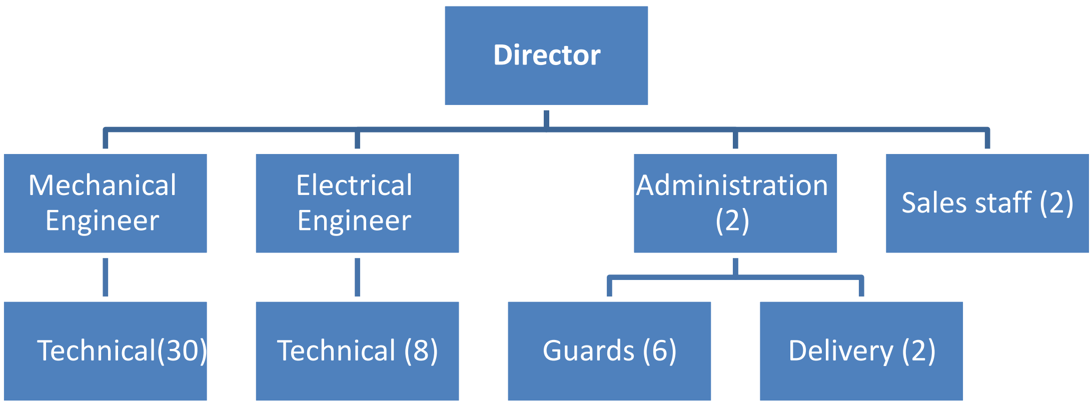
Each of these 6 potential customers shown in Table 5 will be visited by a Company representative at least monthly. Thus there will be 72 representative visits per year. Since each representative can make 4 visits per week the Company requires not less than 2 sales representatives (allowing for sickness, holidays, training, etc). Customers will be informed by representatives of the Company and its products. In addition, we will advertise in chemical industry and other daily newspapers. The Company will also advertise and take customer enquiries via a web-site. In addition, to their primary role in selling and taking orders, the representatives will follow-up orders with the customer to gauge customer satisfaction. It will be a key role of representative to investigate directly with customers any decline or cessation in customer orders.

Table 5: Potential customers

Name	Location	Sector	MEA	DEA	TEA
Oil & gas refinery company	Kerkuk	gas scrubbing	Yes	No	No
Dora refinery company	Baghdad	gas scrubbing	Yes	No	No
Basra refinery company	Basra	gas scrubbing	Yes	No	No
CO2 producing companies	Baghdad, Babylon Karbala, Kufa , Basra & others	gas scrubbing	Yes	No	No
Vegetable oils company	Baghdad	Cosmatics	Yes	Yes	No
Modern Paints company	Baghdad	Emulsion paints	Yes	Yes	Yes
Industrial plastics company	Baghdad & Nineveh	Industrial plastics	Yes	No	Yes
Drugs general company	Samara	Antibiotic	No	Yes	Yes

Organization

Company structure is shown in the Organization Chart below:



APPENDIX 1 BACKGROUND

This material has special importance owing to its wide use in scrubbing hydrogen sulfide (H_2S) and carbon dioxide (CO_2) from petroleum gas streams. It is a family of surfactants or solvent useful to produce emulsion paints, dispersing agents from agricultural chemicals, light duty detergents and personal care products. It is also used as chemical intermediate for resins, plasticizers corrosion inhibitor, rubber chemicals, lubricants, cutting fluids for pharmaceuticals and textile softening agents so constructing a plant to produce such material will certainly supply the local market with an important material needed in petroleum gas industry and carbon dioxide manufacturing factories in addition to their need in different chemical industries.

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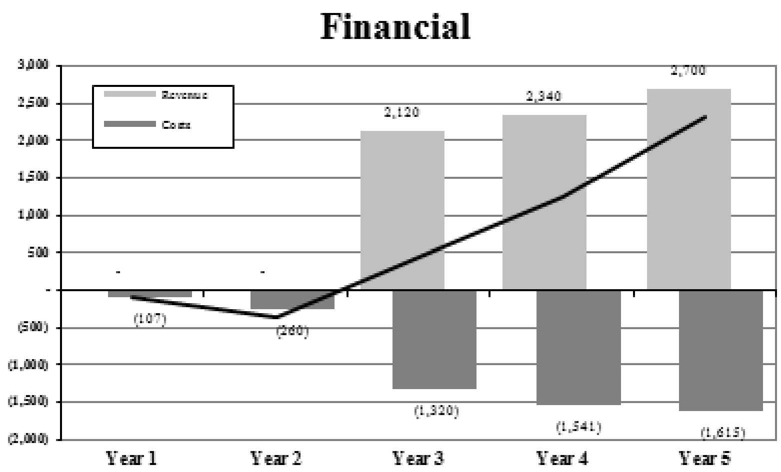
Financial

Table 6: Summary financial modeling

	Year 1	Year 2	Year 3	Year 4	Year 5
	£'000	£'000	£'000	£'000	£'000
Sales Revenue	-	-	2,120,000	2,340,000	2,700,000
Cost of Sales	-	(150,000)	(1,197,736)	(1,415,122)	(1,485,878)
Gross Profit	-	(150,000)	922,264	924,878	1,214,122
Employee costs	(48,600)	(49,815)	(51,060)	(52,337)	(53,645)
Other operating costs	(58,467)	(60,498)	(71,587)	(73,436)	(75,162)
Total operating costs	(107,067)	(110,313)	(122,648)	(125,773)	(128,807)
Operating Profit	(107,067)	(260,313)	799,616	799,105	1,085,315
R&D	-	-	-	-	-
EBIT	(107,067)	(260,313)	799,616	799,105	1,085,315
Interest payments	-	-	-	-	-
Profit Before Tax	(107,067)	(260,313)	799,616	799,105	1,085,315
Add: Depreciation	93,200	183,340	184,480	185,147	186,247
Less: Capital Expenditure	(913,000)	(900,700)	(10,700)	(13,700)	(10,700)
Net Working Capital Investment	-	-	(212,000)	(234,000)	(270,000)
Tax	-	-	-	-	-
Net Cash Flow	(926,867)	(977,673)	761,396	736,551	990,862
Cumulative Net Cash Flow	(926,867)	(1,904,539)	(1,143,143)	(406,591)	584,270
Peak Funding Requirement	-	(1,904,539)	-	-	-



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APPENDIX 2: PRODUCTS

Description of the products:

The products with their annual amounts produced are :

Monoethanolamine 1000 ton
Diethanolamine 357 ton
Triethanolamine 71.4 ton

For the main product (Monoethanolamine) the annual amounts produced is sufficient to cover the need of petroleum gas refinery establishment and carbon dioxide production factories while some of the amounts of Diethanolamine and Triethanolamine could be used in adhesives, cement and anti-corrosion industry and the superabundance of the three products could be exported abroad .

Preliminary technical study :

Specification of machines used is as follows:

Type	volume	steel type
reactor	3 m^3	st, jacketed
NH_3 absorber	5 m^3	c.st
NH_3 dehydrator	5 m^3	c.st
MEA reservoir	10 m^3	c.st
DEA reservoir	10 m^3	c.st
TEA reservoir	10 m^3	c.st

The process flow sheet diagram is shown below:
The machines will be allocated on sketch of the plant in large workshop with 20 m width ,
100 Length and 13 m height.

Raw material availability:

- Ammonia : is well available with a price of 120 $ / ton
- Ethylene oxide : could be either imported with a price of 0.52 $ / pound (1146 $ / ton) or could be produced in another project . However ethylene oxide production needs only oxidation of ethylene (which is well available in our country with a price of 3 cent / pound) with air or oxygen using silver catalyst in a tubular reactor .

Total quality management:

Analysis of Monoethanolamine, Diethanolamine and Triethanolamine to determine purity could be done using either CHN or Chromotography or by classical methods. For Monoethanolamine it is necessary (according to iso system) that its purity should be not less than 99.5 %

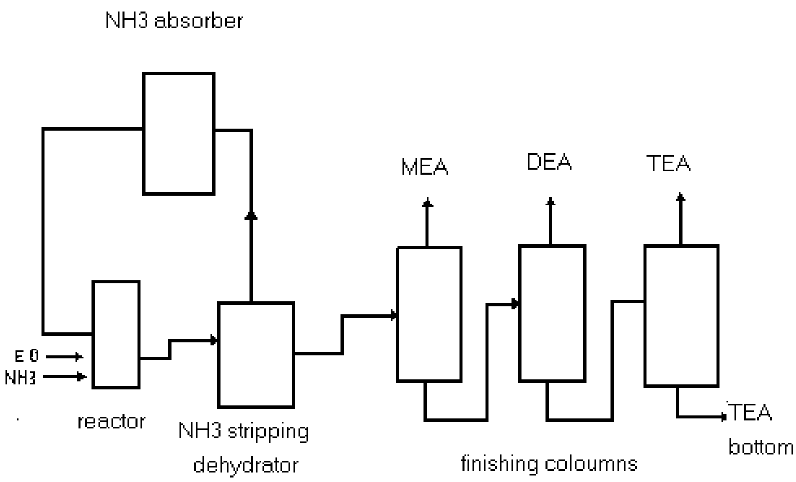
APPENDIX 3: MANUFACTURING PROCESS

Process description

Today ethanolamines are produced on an industrial scale by reaction of ethylene oxide with excess ammonia being considerable in some cases.

In all conventional processes, reaction takes place in liquid phase, and the reaction pressure must be sufficiently large to prevent the vaporization of ammonia at the reaction temperature . In the current procedure ammonia concentration in water between 50 and 100%, pressure of 160 atmosphere and the reaction up to 150 C is used .

The flow sheet for production of MEA is as shown in the diagram. raw materials used are ammonia and ethylene oxide . Aqueous solution of ammonia is mixed with recycled stream of ammonia to get a concentration of 30% ammonia in water, which is mixed with ethylene oxide and sent to reactor(plug flow reactor) . Reaction temperature of 150 C is maintained in the reactor, and a pressure of 160 atmosphere to avoid the evaporation of ammonia and hence to keep ammonia liquid solution to carry the reaction in liquid phase.



Flow sheet for monoethanolamine production

EO = ethylene oxide MEA = monoethanolamine

DEA = diethanolamine TEA = triethanolamine

Reactor:

Reaction between ethylene oxide and ammonia is exothermic with release of 125 KJ/mole of ethylene oxide. Hence in order to maintain the reaction temperature heat has to be removed which passing the cooling water the jacket covering the reactor dose. Here in the reactor all the amines are produced i,e. MEA, DEA and TEA . In order to enhance the production of MEA ammonia must be passed in excess to provide the ammonical environmental. Product distribution of three ethanolamines can be controlled by appropriate choice of ammonia: ethylene oxide ratio . Under appropriate conditions of reaction MEA formed will be 70% , DEA 20% and TEA 5% . For the safety reasons, ethylene oxide must be metered into ammonia stream: in the reverse procedure, ammonia or amine may cause ethylene oxide to undergo an explosive polymerization reaction.

Flash:

The product coming out of the reactor is sent the flash to remove excess ammonia used, is recycled. Reactor outlet stream will be having the temperature of 150 C and at the same pressure as in the reactor. Hence at the lower pressure, at one atmosphere ammonia is completely removed. Feed before entering the flash it is passed through a heat exchanger to remove the excess heat present than what is required for the removal of ammonia . It is taken that no water is lost in the flash, only ammonia is removed.

Dehydration Tower:

In this almost all the water interring in the feed is removed as top product . Only a negligible amount of MEA will be lost because of very large difference in the boiling point of DEA and TEA they come down as the feed enters, and hence separation occurs only between Monoethanolamine and Water .

Monoethanolamine tower:

Amount of water present in the feed for this tower which coming from the dehydration tower is very small is in negligible amount. Here in this column Monoethanolamine is taken as top product and mixture of both DEA and TEA coming out as bottom product, further are sent vacuum column for their separation Monoethanolamine of 99% purity is obtained. Only a small fraction of DEA and water is coming along with the

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MEA.

World Uses of MEA, DEA and TEA:

MEA: An intermediate in the manufacture of cosmetics, surface-active agents , emulsifiers , and plasticizing agents; a gas – scrubbing agents for absorption and removal of H_2S and CO_2 from refinery and natural gas streams ; carbon dioxide and ammonia manufacturing .

DEA: An intermediate in the manufacture of cosmetics; surface – active agents used in household detergents and textile specialties; insecticides and herbicides; petroleum demulsifies; as a gas scrubber in refinery and natural gas operations; waxes, polishes, and coatings emulsifiers; soluble oils and corrosion inhibitor.

TEA: An intermediate in the manufacture of surface –active agents used in textile specialties , waxes and polishes , herbicides petroleum demulsifies, toilet goods, cement additives cutting oils photographic – film developers; corrosion inhibitor; dispersant for dyes , casein , shellac, and rubber latex ; sequestering agents ; and rubber chemical intermediate .

Percentage Uses of Ethanolamine:

In our study we restricted our attention to CO_2 producing and H_2S scrubbing as main uses of monoethanolamine because of some specialty accompanied our industry in Iraq but if we look forward it is necessary to mention the world uses of ethanolamines (MEA,DEA and TEA) and percentage of uses being as follows :

Detergents ,32 % ; ethyleneamines, 20 % ; gas purification, 17 % ; metal cleaning , 10 % ; herbicide intermediate , 10 %; textile , 5 % ; miscellaneous ,including cement grinding oils and pesticide emulsifiers , 6 %

Raw materials needed:

1- Ammonia: available in its anhydrous or aqueous state .

2- Ethylene oxide : could be prepared from 2-chloro ethanol and aqueous potassium hydroxide , or as now it is produced by direct oxidation of ethylene to ethylene oxide using silver catalyst , this material can easily be imported , however this material is also an important chemical because ethylene oxide is an important chemical yielding ethylene glycol (half of the ethylene oxide produced being consumed for this aspect) ethanolamines , acrylonitrile , about one fifth of all ethylene oxide is still being made by the old process through chlorohydrin , but an increasing amount each year is manufactured by air or oxygen acting on pure ethylene .

$$C_2H_4 + 1/2\ O_2 \xrightarrow[\text{125-300 psi}]{\text{400-600 F}} C_2H_4O \quad \text{enthalpy=-35 Kcal}$$

Catalyst yield 55-56 % conversion per pass 25-50%
More recently the chlorohydrine route to ethylene oxide and glycol has been superseded – at least in new plants construction – by the reaction of ethylene with oxygen and water

$$C_2H_4 + 1/2\ O_2 \longrightarrow \underset{\text{ethylene oxide}}{C_2H_4O} \quad \text{yield 60\%}$$

$$C_2H_4O + H_2O \longrightarrow \underset{\text{ethylene glycol}}{CH_2OH.CH_2OH} \quad \text{yield 92-95\&}$$

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