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The History, Current Developments, and Upcoming Obstacles of Sustainable Chemistry

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ABSTRACT

Sustainable chemistry are of the organic chemistry chemicals are some of the important starting materials for a great number of major chemical industries. Sustainable chemistry is an approach to chemistry that goals to maximize efficiency and minimize dangerous results on human health. Sustainable chemistry with its 12 principles would like to see changes in the conventional ways that were used for decades make synthetic organic chemicals and the use of less toxic starting material. Green solvents are environmentally friendly solvents which are derived from the processing of agricultural crops. Historical context of sustainable chemistry , father of sustainable chemistry 'Paul Anastas'.There are various scope, challenges and future of sustainable chemistry. Sustainable chemistry with its 10 reasons why sustainable chemistry is important. Applications and environmental chemistry some advantages and disdvantages of sustainable chemistry. It is very neccsary, important in our daily life. Computrer chips have many chemicals, large amounts of water and energy are required. Greeen chemistry application in industry, Chemical industry involves major chemicals, reagents, solvents, catalysts and almost all types of organic reactions for synthesis of active pharmaceutical substances. Old synthesis of ibuprofen ,new synthetic roots with only three steps and increased efficiency, adipic acid ad its efficiency of the sustainable chemistry. How innovation occure. Finally, the success of Sustainable chemistry ultimately depends on the practicing chemists who will use the same brilliance and creativity that is the long tradition of chemistry and use it with the new perspective for transformative innovations for sustainability.

Key Words : Sustainable chemistry, Twelve Principle , Scope , Ibuprofin Synthetic , Innovation, Paul Anastas.

INTRODUCTION

- Defination

Sustainable chemistry is an approach to chemistry that goals to maximize efficiency and minimize dangerous results on human health.(G)

- Examples
- Green solvents.
- Synthetic techniques.
- Carbon dioxide as blowing agent.
- Hydrazine.
- 1,3-Propanediol

FIG 1 ;GREEN CHEMISTRY

Sustainable chemistry:

- Prevents pollution at the molecular level
- Is a philosophy that applies to all areas of chemistry, not a single discipline of chemistry.
- Applies innovative scientific solutions to real-world environmental problems
- Results in source reduction because it prevents the generation of pollution
- Reduces the negative impacts of chemical products and processes on human health and the environment
- Lessens and sometimes eliminates hazard from existing products and processes
- Designs chemical products and processes to reduce their intrinsic hazards

Principles of sustainable chemistry:

1: Waste Prevention:

This tenet simply states that chemical techniques must be optimized to produce the minimal quantity of waste possible. A metric, called the environmental element (or E element for short), turned into evolved to gauge the quantity of waste a technique created, and is calculated by clearly dividing the mass of waste the manufacturing method produces by the mass of product received, with a decrease E element being better. Drug production methods historically had notoriously excessive E factors, but the application of a number of the other sustainable chemistry principles can help to reduce this. Other techniques of assessing amounts of waste, such as comparing the mass of the raw materials to that of the product, are also used

2: Atom Economy:

Atom economy is a measure of the quantity of atoms from the starting material which are present in the beneficial products at the stop of a chemical process. Side products from reactions that aren't beneficial can lead to a lower atom economic system, and extra waste. In many ways, atom economy is a higher degree of reaction efficiency than the yield of the reaction; the yield compares the amount of useful product received compared to the amount you'd theoretically expect from calculations. Therefore, processes that maximize atom economy are preferred.

3: Less Hazardous Chemical Synthesis:

Ideally, we want chemicals we create for whatever purpose to not pose a health danger to humans. We also need to make the synthesis of chemicals as safe as possible, so the purpose is to avoid using dangerous chemical compounds as starting points if safer options are available. Additionally, having dangerous waste from chemical processes is some thing we want to keep away from, as this can cause issues with disposal.

4: Designing Safer Chemical:

This principle links closely to the previous one. Chemists must aim to produce chemical products that fulfil their role, be that medical, industrial, or otherwise, but which also have minimal toxicity to humans. The design of safer chemical targets requires a information of how chemicals act in our bodies and in the environment. In some cases, a degree of toxicity to animals or humans may be unavoidable, but options should be sought.

5: Safer Solvents & Auxiliaries:

Many chemical reactions require the use of solvents or other agents in order to facilitate the reaction. They can also have a number of hazards associated with them, such as flammability and volatility. Solvents might be unavoidable in most processes, but they should be chosen to reduce the energy needed for the response, should have minimum toxicity, and should be recycled if possible.

6: Design for Energy Efficiency:

Energy-intensive techniques are frowned upon in sustainable chemistry. Where it is possible, it is better to minimise the power used to create a chemical product, by carrying out reactions at room temperature and pressure. Considerations of response layout also need to be made; **7: Use of Renewable Feedstocks:**

The perspective of this principle is largely towards petrochemicals: chemical products derived from crude oil. These are used as starting materials in a range of chemical processes, but are non-renewable, and can be depleted. Processes can be made extra sustainable by the use of renewable feedstocks, such as chemical compounds derived from organic sources.

8: Reduce Derivatives:

Protecting groups are often used in chemical synthesis, as they can prevent alteration of certain parts of a molecule's structure during a chemical response, whilst allowing transformations to be done on other components of the structure. However, these steps require more reagents, and also increase the amount of waste a process produces. An alternative that has been explored in some processes is the use of enzymes. As enzymes are highly specific, they can be used to goal specific parts of a molecule's structure with out the need for using protecting groups or other derivatives.

9: Catalysis:

The use of catalysts can enable reactions with higher atom economies. Catalysts themselves aren't used up by chemical strategies, and as such can be recycled many times over, and don't contribute to waste. They can allow for the utilisation of reactions which would not proceed under normal conditions, but which also produce less waste.

10: Design for Degradation:

Ideally, chemical products should be designed so that, once they have fulfilled their purpose, they damage down into innocent products and don't have bad impacts at the environment. Persistent organic pollutants are products which don't break down and can accumulate and persist in the environment; they are usually halogenated compounds, with DDT being the maximum well-known example. Where possible, these chemicals should get replaced of their uses with chemicals that are more easily damaged down by water, UV light, or biodegradation.

11: Real Time Pollution Prevention:

Monitoring a chemical response as it is occurring can help prevent release of dangerous and polluting materials due to accidents or unexpected reactions. With real time monitoring, warning signs may be spotted, and the response may be stopped or controlled before such an event occurs.

12: Safer Chemistry for Accident Prevention:

Working with chemicals always carries a degree of danger. However, if dangers are controlled well, the risk can be minimised. This principle clearly links with a number of the other concepts that discuss hazardous products or reagents. Where possible, exposure to dangers should be eliminated from processes, and should be designed to minimise the risks where elimination is not possible [1]

Scope of Sustainable chemistry

Let us understand how does this field come into the picture? The call itself is sufficient to apprehend its importance. The international nowadays is jogging at a quick tempo and all round us, merchandise are becoming dangerous to our environment. This changed into in no way the case earlier than however that is now taking place because of numerous reasons.

We are eating the goods in huge quantities, so with a purpose to meet the requirement of the goods we're the use of immoderate quantities of uncooked substances and chemical compounds which might be very dangerous to our environment.

The scope of inexperienced chemistry is wide and contains a extensive variety of industries and applications. Some of the regions in which inexperienced chemistry is being implemented include:

Pharmaceuticals: Sustainable chemistry is getting used to expand greater environmentally pleasant and sustainable techniques for the synthesis of medicine and different pharmaceutical merchandise.

Cosmetics: Sustainable chemistry is getting used to expand more secure and extra sustainable components to be used in cosmetics and private care merchandise.

Agriculture: Sustainable chemistry is getting used to expand extra sustainable techniques for generating fertilizers, pesticides, and different agricultural chemical substances.

Manufacturing: Sustainable chemistry is getting used to expand greater environmentally pleasant strategies for generating chemical substances, plastics, and different substances utilized in manufacturing.

Energy: Sustainable chemistry is getting used to expand greater sustainable and green techniques for generating electricity, along with renewable power reassets like sun and wind power.

Overall, the intention of inexperienced chemistry is to limit the environmental effect of chemical merchandise and processes, even as nevertheless assembly the wishes of society. By making use of the concepts of inexperienced chemistry, it's miles feasible to lessen pollution, preserve herbal resources, and sell monetary boom and innovation [4]

Oxidation reagent and Catalysts Though there is notable advancement in oxidation chemistry, but it is still one of the most polluting chemical technology. Oxidative transformations, as course be to use and generation of non-hazardous substances, with maximum efficiency of atom incorporation. et al Int J Sci Res Sci & Technol. September-October-2022, 9 (5) : 406-409 Combitional Green Chemisty Combinatorial chemistry is a practice of being able to make a large number of chemical compounds rapidly on a small scale through reaction matrices. This practice is used on a large scale in the pharmaceutical sector. In case, a pharmaceutical company identifies a compound (lead compound), which has considerable promise (as far as its biological activity is concerned) then the company would proceed in making a large number of derivatives of the lead compound and test their efficacy. In this way, the potential of a compound will be optimized. The combinatorial chemistry has enabled large number of substances to be made and screened for their activities without having any adverse effect on the environment.

In the context of sustainable chemistry, combinatorial approach is very useful to assess the biodegradability of the products. For example, if a company has struck on a biodegradable pesticide, then combinatorial approach will be helpful to make large number of other compounds, which will have the required pesticidal activity along with biodegradability. Proliferaton of solventless reactions. A large number of reactions occur in solid phase without the use of solvents are not harmful to the environment. In fact, a number of solventless reactions occur more efficiently with more selectivity compared to reactions carried out using solvents. Such reactions are simple to handle, reduce pollution and are comparatively cheaper to operate.

The reaction can be conducted either by heating the reactant. Alternatively, a solution of the reactants in suitable solvent (like water, alcohol, methylene chloride etc.) is stirred thoroughly with a suitable adsorbent or solid support like silica, gel, alumina, phyllosilicate. After stirring the solvent is removed in vacuo and the dried support on which the reactants have been adsorbed are used to carry out the reaction under microwave irradiation Sustainable chemistry in Sustainable Development Sustainable development means development, which meets the needs of the present without compromising the ability of the future generations to meet their own needs. The Earth Summit was held on June 3-14, 1992 at Rio de Janeiro. This was attended by delegates including 150 Heads of States. The International Community adopted Agenda 21. This was a landmark achievement, which incorporated economic and social concerns. It contained a wide variety of recommendations on the following issues:

i. Reducing wasteful use of natural resources.

ii. Fighting poverty. Protecting the atmosphere, oceans, plant and animal life.

iii. Promoting sustainable agricultural practices for feeding the ever increasing population of the world. development, is, in fact, related to sustainability of our natural resources. The most obvious concern for the extensive utilization of limited or depleting resources is the fact, that by definition, they can run out or become exhausted. Such resources are not regarded as sustainable either from environment or from economic point of vi… [5]

Solvent extraction of free chemistry

Green solvents usually are used in the enzyme-assisted extraction methodology, which are the solvents with lowest toxicity such as acetone, ethanol, methanol, 2-propanol, ethyl acetate, isopropyl acetate, methyl ethyl ketone, 1-butanol, and tert-butanol [G]

Green Solvents

Green solvents are environmentally friendly solvents, or biosolvents, which are derived from the processing of agricultural crops. The use of petrochemical solvents is the key to the majority of chemical processes but not without severe implications on the environment. Green solvents were developed as a more environmentally friendly alternative to petrochemical solvents. Ethyl lactate, for example, is a green solvent derived from processing corn. Ethyl lactate is the ester of lactic acid. Lactate ester solvents are commonly used solvents in the paints and coatings industry and have numerous attractive advantages including being 100% biodegradable, easy to recycle, noncorrosive, noncarcinogenic, and nonozone-depleting. Ethyl lactate is a particularly attractive solvent for the coatings industry as a result of its high solvency power, high boiling point, low vapor pressure, and low surface tension. It is a desirable coating for wood, polystyrene, and metals and also acts as a very effective paint stripper and graffiti remover. Ethyl lactate has replaced solvents such as toluene, acetone, and xylene, resulting in a much safer workplace. Other applications of ethyl lactate include being an excellent cleaner for the polyurethane industry. Ethyl lactate has a high solvency power, which means it is able to dissolve a wide range of polyurethane resins. The excellent cleaning power of ethyl lactate also means it can be used to clean a variety of metal surfaces, efficiently removing greases, oils, adhesives, and solid fuels. The use of ethyl lactate is highly valuable, as it has eliminated the use of chlorinated solvents. [2]

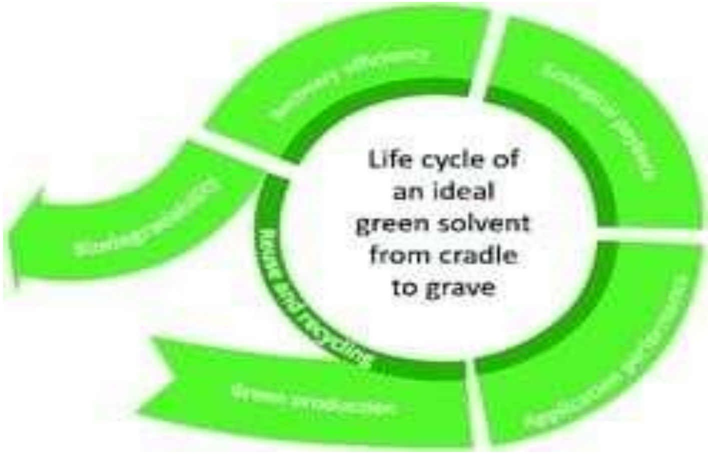


Fig 2 life cycle of green solvents

Challenges in Sustainable chemistry:

There are several challenges that sustainable chemistry may also face as it maintains to evolve and develop in importance. Some of the key challenges include:

Financial barriers: The development of new technology and processes often requires significant investments in research and improvement. This can be a major challenge for small companies or startups that may not have the necessary financial resources. Additionally, the adoption of sustainable chemistry may also require significant modifications to traditional production processes and deliver chains, which can be costly.

Regulatory barriers: Sustainable chemistry may face regulatory and policy barriers that can prevent its adoption and implementation. For example, a few governments may also have previous regulations that do not fully recognize the advantages of inexperienced chemistry or may also lack incentives to inspire the adoption of sustainable practices.

Consumer skepticism: Sustainable chemistry may also face skepticism or resistance from consumers who aren't familiar with the benefits of sustainable products and strategies. This may be a challenge if consumers are not willing to pay a top class for eco-friendly products or if they are skeptical about the effectiveness of these products.

Limited information and expertise: The improvement of sustainable chemistry requires a deep understanding of chemical reactions and processes, as well as the capacity to design and develop sustainable products and processes. This can be a challenge if there is a lack of knowledge and expertise in this area.

Collaboration and partnerships: Sustainable chemistry often requires collaboration and partnerships with various stakeholders, including industry, academia, governments, and NGOs. This may be a challenge if there is a lack of communication and coordination amongst these groups.

Overall, sustainable chemistry faces a number of challenges, but with the right resources and support, it has the ability to bring big benefits to the environment and society.

Sustainable chemistry can be useful to the surroundings and it can save our life too. Many products are manufactured by using traditional techniques, but it is not good for our surroundings. In this case, sustainable chemistry will be the fine choice for us. [6]

Future of sustainable chemistry:

The destiny of inexperienced chemistry appears bright, because the area maintains to adapt and develop in significance. Here are some key developments and tendencies which might be in all likelihood to form the destiny of inexperienced chemistry:

Increased recognition on sustainability: As the sector will become an increasing number of privy to the want to shield the surroundings and herbal resources, there could be extra call for for sustainable and green merchandise and techniques. Sustainable chemistry is well-located to satisfy this call for, as it's far centered at the layout and improvement of chemical merchandise and methods which might be environmentally pleasant and sustainable.

Continued technological advancements: Sustainable chemistry will maintain to advantage from advances in technology, as new equipment and strategies come to be to be had to aid the layout and improvement of extra sustainable chemical merchandise and techniques. This can also additionally consist of the improvement of latest materials, the use of renewable resources, and using superior analytics and data-pushed procedures to optimize chemical reactions.

Growing regulatory help: Governments round the arena are starting to apprehend the significance of inexperienced chemistry and are taking steps to sell the usage of sustainable and green merchandise and techniques. This might also additionally consist of the adoption of recent policies and standards, the introduction of incentives and subsidies, and the improvement of partnerships and collaborations with enterprise and academia.

Increased collaboration and partnerships: The destiny of inexperienced chemistry will depend upon the capacity of stakeholders from numerous sectors to paintings collectively and proportion expertise and expertise. This can also additionally consist of collaborations among enterprise and academia, in addition to partnerships among governments, NGOs, and different stakeholders.

Overall, the destiny of inexperienced chemistry appears bright, because the subject maintains to conform and develop in significance. As the sector turns into an increasing number of aware about the want to shield the surroundings and herbal resources, inexperienced chemistry is wellplaced to play a key function in growing sustainable and green merchandise and methods that meet the desires of society[7]

Sustainable chemistry Applications in Industries

Chemical industry involves major chemicals, reagents, solvents, catalysts and almost all types of organic reactions for synthesis of active pharmaceutical substances. Therefore, many chemicals and chemical processes involved are hazardous, toxic and may show adverse effects on human health and environment. Pharmaceutical companies can influence and improve the environmental performance with utilizing sustainable chemistry. Sustainable chemistry is being employed to develop revolutionary drugdelivery methods that are more effective and less toxic and could benefit millions of patients. Sustainable chemistry has grown from a small idea into a new approach to the scientifically based environmental protection. By using sustainable chemistry procedures, we can minimize the waste of materials, maintain the atom economy and prevent the use of hazardous chemicals. Researchers and pharmaceutical companies need to be encouraged to consider the principles of sustainable chemistry while designing the processes and choosing reagents.

Waste minimization in drug discovery

Green Technologies in the Pharmaceutical Industry

Environmental and Regulatory Aspects

Food & Flavor Industry

Paper & Pulp Industry

Polymer Industry

Sugar & Distillery Industries

Textile and Tannery Industry [12]

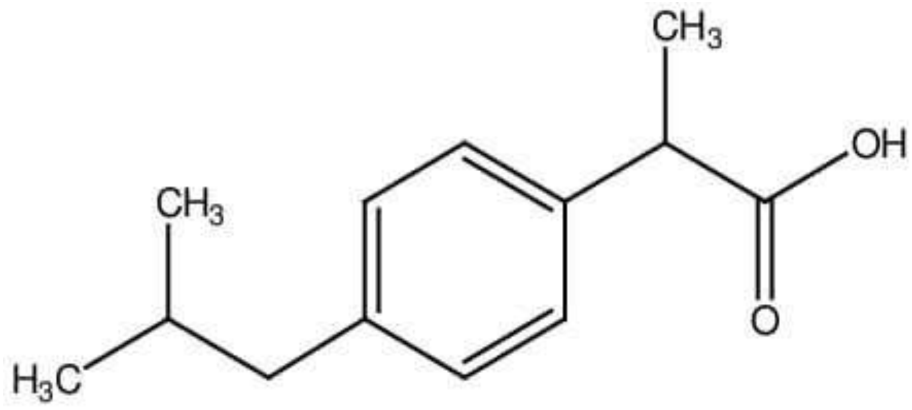
Fig 1.1 Conservative Chemistry

Old synthesis of ibuprofen

Ibuprofen was synthesized in 1960 by the pharmaceutical company Boot (England) and sold under the

commercial name Aspro, Panadol and Nurofen. The synthesis of Ibuprofen was performed in six steps with the production of secondary by-products and waste. The main problem according to the scientists

at the time was that this synthesis had a very “poor atom economy”



Ibuprofen

New synthetic route with only three steps and increased efficiency. The atoms of the starting chemicals are incorporated into the products of the reactions and waste is minimised. In both synthetic routes the starting chemical is 2-methylpropylbenzene, which is produced from the petrochemical industry. The innovation in the new method was in the second step. A catalyst of Nickel (Raney nickel) was used thus decreasing substantially the steps of the synthesis.

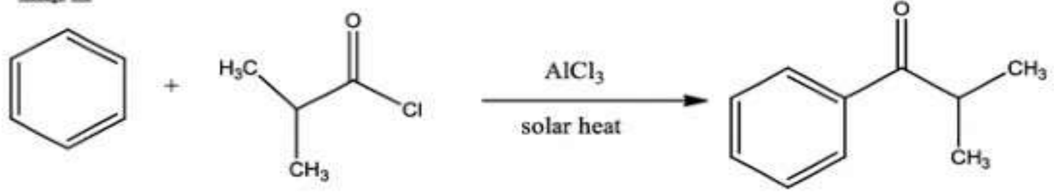
In the old synthetic route, each step had a yield of 90% so that the final product came to be 40% yield compared to the starting chemical. This resulted in the increased production of by-products as waste.

The drug was produced annually (only in Great Britain) in 3.000 tones and we understand that substantial amounts of chemicals were lost as waste. Energy also was lost by the low efficiency of the reaction method. In the "greener' method of three steps the final yield is 77%, whereas the

Raney nickel catalyst (Nickel, CO/Pt) can be recycled and reused. In the old synthetic route, the AlCl3 used as a catalyst had to be thrown away as waste. The energy requirements of the second method were much lower than the first.

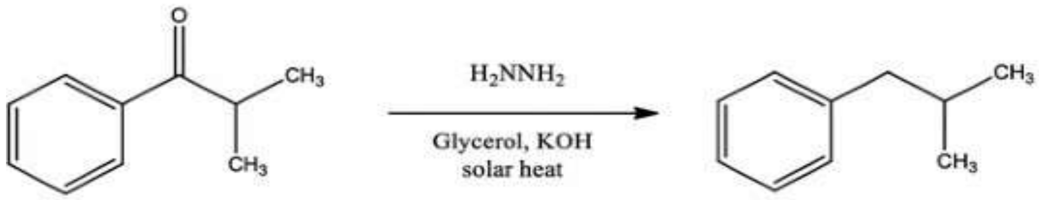
The new synthetic route of Ibuprofen is a classic example of how Sustainable chemistry ideas can influence to the better the industrial synthetic methods, not only from the point of economic efficiency, but also from the point of more effective science and technology methods .[13]

Step 1:



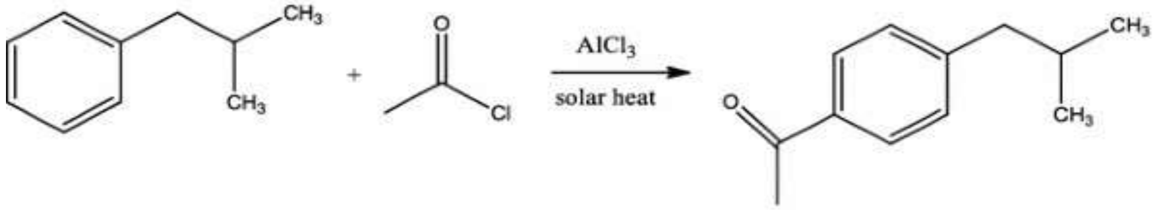
isobutyrophenone

Step 2:



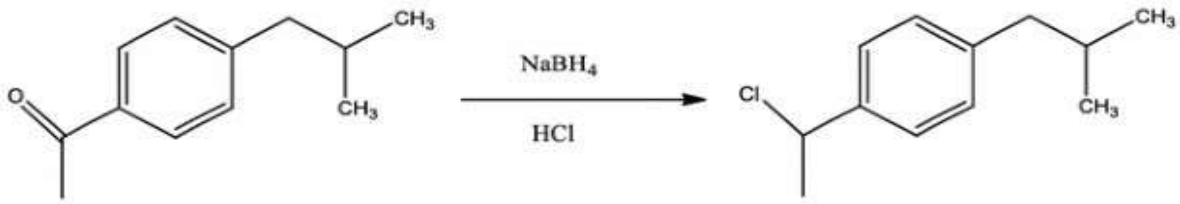
isobutyl benzene

Step 3:



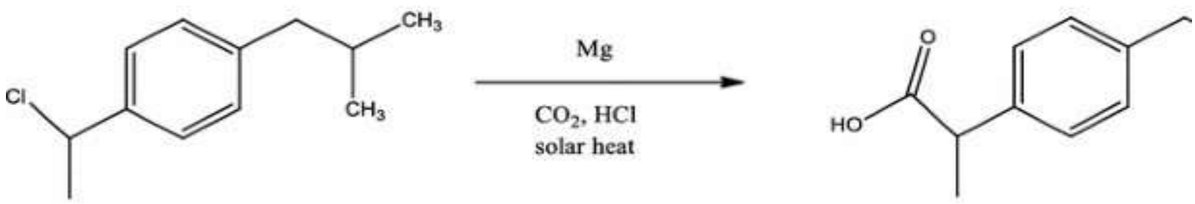
isobutylacetophenone

Step 4:



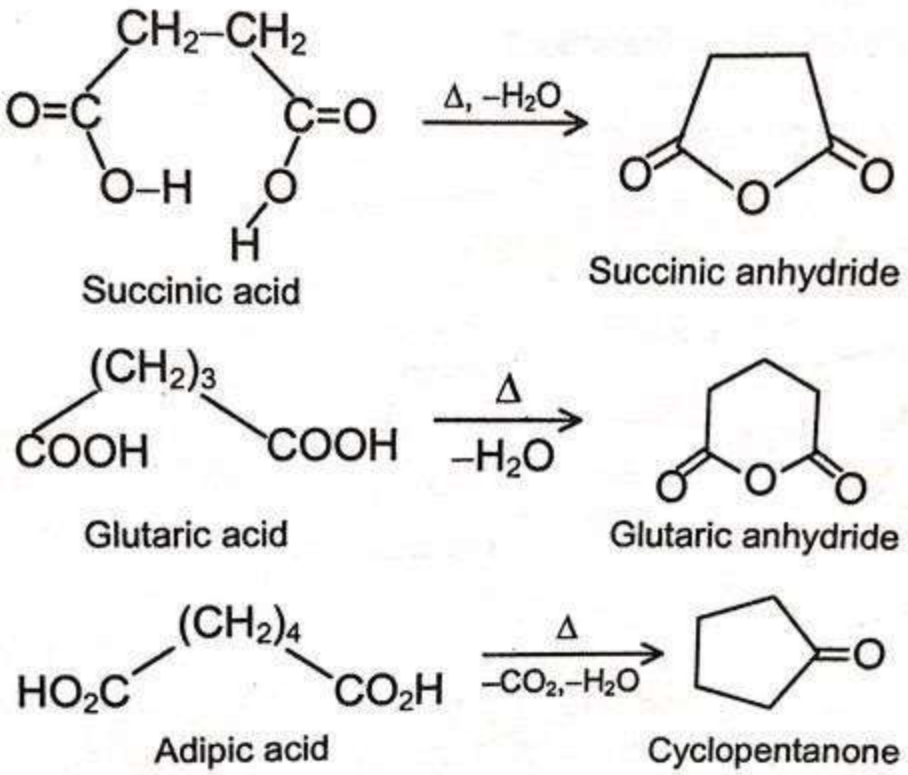
1-chloro-1-(4-isobutylphenyl)ethane

Step 5:



ibuprofen

New synthesis of Adipic acid



4. The Efficiency of the Green Method of Adipic Acid

The Adipic acid synthesis by the two methods can be used as a good example for the "atom economy"

(atom or mass efficiency) of reactions in synthetic routes.

A. The "old", traditional method for the Adipic acid with cyclohexanone/cyclohexanol oxidation by Nitric acid. In the presence of catalyst copper/vanadium [Cu(0.1-05% & V (0.02-0.1%)] The reaction is:

C6H12O + 2 HNO3 + H2O C6H10O4 + NOx (NO, NO2, N2O, N2)

In this method the negative aspect is the release of nitrogen oxides. The Yield is 93% If we take into account the mass of the atoms, for reactants and product, we can have the following calculations:

Product mass = (6C) (12) (10H) (1) (4O) (!6) = 146 g Reactant mass = (6C)

(12) (18H) (1) (9O) (16) (2N) (14) = 262 g

Yield or Mass efficiency of the reaction, is the ratio of product/reactants X 100 = 146/262 X 100 = 55,7%

The new "greener" method The preparation from cyclohexene oxidized by H2O2 in the presence of the catalyst Nα2WO4.2H2O (1%) with solvent Aliquat 336 [CH3 (ν-C8H17)3N] HSO4 (1%)].

C6H10 + 4 H2O2 catalysts C6H10O4 + 4 H2O

The new "greener" method does not produce toxic waste and its yield is 90%.

Product mass = (6C) (12) (10H) (1) (4 O) (16) (2N) (14) =146 g Reactant mass = (6C) (12) (18H) (1) (8 O) (16) = 218 g Reaction Mass efficiency = 146/218 X 100 = 67%.

The reaction mass efficiency of the "greener" method is 11% higher than the first method.[14

CONCLUSION:

The ultimate aim of sustainable chemistry is to entirely cut down the stream of chemicals pouring into the environment. We have concluded sustainable chemistry is an approaches to chemistry that goals to maximize efficiency and minimize dangerous results of human health. Sustainable chemistry had 11 principles like to seen changed in the ways that was used for synthetic organic chemicals and the used of less toxic materials. We have concluded scope, challenges and future of sustainable chemistry was very interested scope and future. An excellent features. Sustainable chemistry was its 10 reason why sustainable chemistry is important. Computer chips have many chemicals, large amount of water required. Sustainable chemistry applications in industris. We observed sustainable chemistry was eco-friendly to the nature, environment and living. And also included old synthesis of ibuprofen, adipic acid its efficiency of sustainable chemistry. We had moniter and noted principle graphs of sustainable chemistry, life cycle of an ideal green solvent from cradle to grave, what was aims of sustainable chemistry and relations between environmental chemistry and living things seened by overall data in diagrammatically. Enovation of sustainable chemistry was also occure. CW-chemistry for wellness.

Aq-aqueous and biobased solvents

Cf- chemical footprint

Z-zero waste

We had concluded like that various technique and new development approaches of sustainable chemistry.

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20. https://pubs.rsc.org/en/journals/journalissues/gc#!recentarticles&adv
21. https://in.docworkspace.com/d/sIMC6k-iLAYmkgaEG?sa=00&st=0t
22. https://greenchemistry.yale.edu/about/history-green-chemistry
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