Whitepaper on:

Nanotechnology & AI Application in Fragrance Sector

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Abbreviations

AI	Artificial Intelligence
CAGR	Cumulative Annual Growth Rate
CIRS	Chemical Inspection and Regulation Service
FFDC	Fragrance & Flavour Development Centre
GMP	Good Manufacturing Practices
ISO	International Organization for Standardization
MNP	Micellar Nanoparticles
MSME	Medium, Small and Micro Enterprises
NLC	Nanostructured Lipid Carriers
NP	Nano Perfumes
SLN	Solid Lipid Nanoparticles
VR	Virtual Reality

1 Introduction

1.1 Background

Technology Centre Systems Programme (TCSP) is a national programme undertaken by the Ministry of Micro, Small and Medium Enterprises with the assistance of the World Bank. The programme seeks to enhance the technological and skill base of MSMEs in certain manufacturing sectors to improve the competitiveness of MSMEs, via upgraded and new Technology Centres (TCs).

The objective of the programme is to enhance the productivity of selected MSME clusters by improving their access to manufacturing technology, establishing a strong focus in providing business & technical advisory services, and improving availability & employability of skilled workforce through TCs[1]. As part of the programme, KPMG has been appointed as the Technology Cluster Manager (TCM) to support TCs and undertake technology and cluster development activities.

The objective of TCM is to increase business opportunities for MSMEs through market linkages, enhance the competitiveness of the cluster business environment, increase the number of MSMEs utilizing the services of TCs, develop a financially self-sustainable business model for cluster related services provided by TCs, identify technologies of the selected sector for TCs, evaluate existing training programs & develop new training programs for rollout at TCs, conduct a gap analysis of TCs, strengthen the capabilities of TCs to provide technical advises to their clients, increase awareness amongst stakeholders on Environmental, Health, and Safety (EHS) requirements[2].

1.2 Objective of White paper

This white paper is part of the engagement of KPMG with the Ministry of Medium, Small and Micro Enterprises (MSME) and aims to provide Fragrance sector-specific information such as leading global technologies, and related latest innovation in design, technology or manufacturing processes. This White Paper also highlights the degree of alignment of the current services of the TC with the market needs and recommend a future course of action for the TC to serve the sector in synergy with the ongoing trends. The paper further contains suggestions on the adoption of new technologies in the Fragrance Sector by TCs and MSMEs in the cluster.

[1] DCMSME website, 25 May 2020
[2] DCMSME website, 25 May 2020

2 Nanotechnology in Perfumes

Perfumes are defined as products which give good odour to the product and person on/in which they have been used. But with increasing consumer expectations and awareness the demands from the perfumes have increased. The modern consumer demands are:

1. Multifunctional properties
2. Long lasting results
3. Convenient to use
4. Affordable price

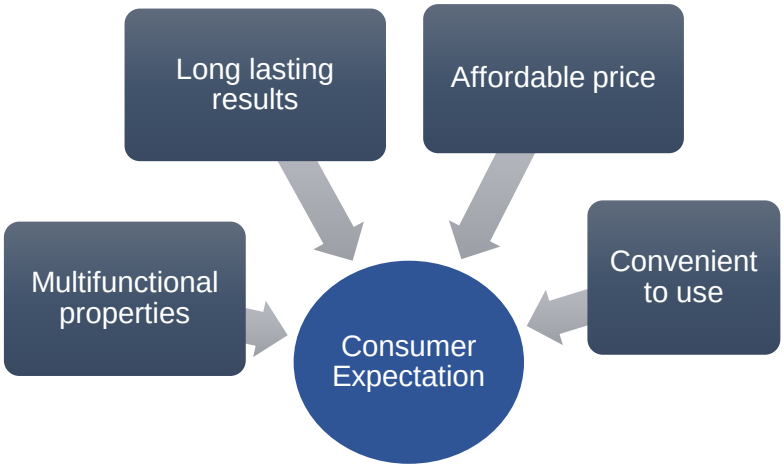

Figure 1: Consumer Expectations

With all these demands the expectations from a perfume company has increased 10 folds over the years. But these expectations have brought with them a challenge for creating an innovative product with best quality, maximum activity and best retentivity at very low cost with high end popular expensive raw materials of best quality. Though these aspects look very lucrative from the marketing point of view but from a perfumer's view point they are nightmare as one must fit the best gems in a diamond encrusted platinum box at the price of a cardboard box. To maintain this balance a perfumer generally looks at various aspects like cheap raw materials or haggling on costs of ingredients or using less concentration of other expensive raw materials but forgets to look at increasing the availability of the expensive ingredients which helps in increasing the activity and also gives cost benefits.

The potency and retentivity of the perfumes can be increased by the modern technologies. But the basic question lies why to use these technologies if we have the existing technology. The answer is:

1. Achieve targeted & timed release of perfumes
2. Enhance efficacy in terms of retention and strength
3. Provide effective concentration
4. To preserve the stability of actives
5. Minimize irritation potential
6. Higher retentivity of fragrances and clarity of product for aesthetically pleasing formulations

Generally, in skin and other sectors Delivery Systems are commonly used. A delivery system is the method of delivering active payloads on to the surface, and then having them pass through the lipid barrier and finally reaching the targeted lower layers beneath. An ideal delivery system generally is nontoxic, carry the actives into substrate, provide controlled release of active, penetrate into the upper stratum corneum layer, improve formulations aesthetically, and allow easy handling of solid and liquid actives and it should be small enough to penetrate into the layers. There are several types of delivery systems which have gained popularity in cosmetic products in last few years. These are as stated below.

1. **Patches:**
   a) Transdermal patches: Though these are present in the market for a long time but its use in the cosmetic market has not been completely explored. These help in providing targeted delivery of actives on the desired areas and help in giving the best effects.
   b) Thin Polymeric films.
2. **Vesicular Carriers:** Liposomes, Niosomes, Ethosomes, Vesicles, microencapsulates are the various vesicular carriers used in drug delivery.

S.No.	Delivery System	Description	Particle Diameter	Materials carried
1	Liposomes	Phospholipid based unilamellar or multilamellar bilayer vesicles	100-500nm	Hydrophillic & Hydrophobic actives
2	Nanodispersions	Phospholipid based cellular dispersion	100-500nm	Hydrophobic actives
3	Vesicles	Surfactant based Vesicles or micelles	100-500nm	Hydrophobic actives
4	Microencapsulates	Aldehyde crosslinked protein	100-5000 microns	Hydrophobic actives

Table 1: Vesicular Carriers

3. **Nanotechnology:**

Nanotechnology is regarded as the most imminent technology of 21st century and is contemplated as a big boon in the cosmetic industry. The term nanotechnology is the combination of two words: namely, technology and the Greek numerical “nano” which means dwarf. Thus, nanotechnology is considered as the science and technology used to develop or manipulate the particles in the size range of 1 to 100 nm. Since 1959, nanotechnology has emerged in different fields like engineering, physics, chemistry, biology, and science and it has been virtually 40 years since nanotechnology has intruded into the field of cosmetics, health products, and dermal preparations.

There are several advantages of nanotechnology. Some of them are listed below:

a) Nanotechnology allows for the controlled release of active substances by controlling the drug release from carriers by several factors including physical or chemical interaction among the components, composition of drug, polymer and additives, ratio, and preparation method.
b) Nano cosmeceuticals make the fragrances last longer, for example, Allure Parfum and Allure Eau Parfum spray by Chanel.
c) Nanotechnology based formulations are more effective and increase the lasting potential of fragrances by having very small size of the particles, the surface area is increased which allows the active transport of the active ingredients into the skin.

d) Nanotechnology based cosmetics have high entrapment efficiency and good sensorial properties and are more stable than the conventional cosmetics. Most of the nanoparticles are suitable for both lipophilic and hydrophilic materials.

There are **various types of Nanotechnology applications** used in the industry, as described below.

a. Liposomes

Liposomes are the vesicular structures having an aqueous core which are enclosed by a hydrophobic lipid bilayer. The main component of liposome lipid bilayer is phospholipids. To protect the drug from metabolic degradation, liposome encapsulates the drug and releases active ingredients in a controlled manner. Liposomes are suitable for delivery of both hydrophobic as well as hydrophilic compounds. Their size varies from 20 nm to several micrometers and can have either multilamellar or unilamellar structure. Liposomes are being developed for the delivery of fragrances, botanicals, and vitamins from anhydrous formulations, such as antiperspirants, body sprays, deodorants etc.

b. Niosomes

Niosomes are defined as vesicles having a bilayer structure that are made up by self-assembly of hydrated nonionic surfactants, with or without incorporation of cholesterol or their lipids. Niosomes can be multilamellar or unilamellar vesicles in which an aqueous solution of solute and lipophilic components are entirely enclosed by a membrane which are formed when the surfactant macromolecules are organized as bilayer. Size ranges from 100 nm to 2 m in diameter. Size of small unilamellar vesicles, multilamellar vesicles, and large unilamellar vesicles ranges from 0.025–0.05 µm, =>0.05 µm, and 0.10 µm, respectively. Major niosomes components include cholesterol and nonionic surfactants like spans, tweens, brijs, alkyl amides, sorbitan ester, crown ester, polyoxyethylene alkyl ether, and steroid-linked surfactants which are used for its preparation. Niosomes are suitable for delivery of both hydrophobic as well as hydrophilic compounds. There is increased stability of entrapped ingredients.

c. Solid Lipid Nanoparticles

Solid lipid nanoparticle (SLN), was developed at the beginning of the 1990s, over the conventional lipoidal carriers like emulsions and liposomes. 50 to 1000 nm is the size range of solid lipid nanoparticles. They are composed of single layer of shells and the core is oily or lipoidal in nature. Solid lipids or mixtures of lipids are present in the matrix drug which is dispersed or dissolved in the solid core matrix. Phospholipids hydrophobic chains are embedded in the fat matrix. These are prepared from complex glycerides mixtures, purified triglycerides, and waxes; liquid lipid is replaced by solid lipid or blend of solid lipid which is solid at body and room temperature and is stabilized by surfactants or polymers. Lipophilic, hydrophilic, and poorly water-soluble active ingredients can be incorporated into SLNs which consist of physiological and biocompatible lipids. Two principle methods for preparation of SLNs are high pressure homogenization method and precipitation method. Controlled release and sustained release of the active ingredients is achieved by SLN. SLNs have UV resistant properties and act as physical sunscreens on their own, so improved photoprotection with reduced side effects can be achieved when they are combined with molecular sunscreen. Other limitations of SLN like reducing particle concentration and expulsion of drug during storage.

d. Nanostructured Lipid Carriers (NLC)

NLC are prepared through blending by solid lipids along with incompatible liquid lipid leading to amorphous solids in ratio of 70:30 up to 99.9:0.1 being solid at body temperature. The particle size ranges from 10 to 1000 nm. They possess numerous advantageous like increased skin hydration due to occlusive properties, and the small size ensures close contact to the skin surface leading to the increased amount of drug penetration into the skin. They allow for stable drug incorporation during storage and an enhanced UV protection system with reduced side effects.

e. Nano-emulsions

Nano-emulsions are thermodynamically stable dispersion of liquid in which an oil phase and water phase are in combination with a surfactant. Depending on the composition different types of nano-emulsions are oil in water, water in oil, and bicontinuous nano-emulsion. They exhibit various sizes ranging from 50 nm to 200 nm. These are dispersed phase which comprises small particles or droplets, having very low oil/water interfacial tension. They have lipophilic core, which is surrounded by a monomolecular layer of phospholipids, making it more suitable for delivery of lipophilic compounds. Nano-emulsions are transparent or translucent and show properties like low viscosity, high kinetic stability, high interfacial area, and high solubilization capacity. Nano-emulsions are widely used as medium for the controlled delivery of various cosmeceuticals like deodorants, hair products etc.

f. Gold Nanoparticles

Nanogold or gold nanoparticles has sizes ranging from 5 nm to 400 nm. They exhibit different shapes such as nanosphere, nanoshell, nanocluster, nanorod, nanostar, nanocube, branched, and nanotriangles. Shape, size, dielectric properties, and environmental conditions of gold nanoparticles strongly affect the resonance frequency. The color of nanogold ranges from red to purple, to blue and almost black due to aggregation. Gold nanoparticles are inert in nature, highly stable, biocompatible, and noncytotoxic in nature. They have high drug-loading capacity and can easily travel into the target cell due to their small size and large surface area, shape, and crystallinity

g. Nanospheres

Nanospheres are the spherical particles which exhibit a core-shell structure. The size ranges from 10 to 200 nm in diameter. In nanospheres, the drug is entrapped, dissolved, attached, or encapsulated to the matrix of polymer and drug is protected from the chemical and enzymatic degradation. The drug is physically and uniformly dispersed in the matrix system of polymer. The nature of the nanospheres can be crystalline or amorphous. The core of nanospheres can be enclosed with diverse enzymes, ingredients, and drugs.

Nanospheres can be divided into two categories: biodegradable nanospheres and nonbiodegradable nanospheres. Biodegradable nanospheres include gelatin nanospheres, modified starch nanospheres, and albumin nanospheres and nonbiodegradable nanospheres include polylactic acid, which is the only approved polymer.

h. Dendrimers

Dendrimers are highly branched, unimolecular, globular, micellar nanostructure, and multivalent nanoparticles whose synthesis theoretically affords monodisperse compounds. A dendrimer is built from a core on which one or several successive series of branches are engrafted in an arborescent way and often adopts a spherical three-dimensional morphology. Generation of the dendrimer is determined by total number of series of branches: if it has one series of branches, then it is first-generation dendrimer; if it has two series, then it is second generation and so on. They are extremely small in size, having diameters in the range of 2–20 nm. Its properties are monodispersity, polyvalence, and stability make it an ideal carrier for drug delivery with precision and selectivity. Dendrimers provide controlled release from the inner core and drugs are incorporated in interior as well as being attached on the surface.

i. Cubosomes

Cubosomes are the advanced nanostructured particles which are discrete, submicron, and self-assembled liquid crystalline particles of surfactants with proper ratio of water that provides unique properties. Cubosomes are formed by self-assembled structures of aqueous lipid and surfactant systems when mixed with water and microstructure at a certain ratio. Cubosomes are bicontinuous cubic liquid phase, which encloses two separate regions of water being divided by surfactant-controlled bilayers and wrapped into a three dimension, periodic, and minimal surface, forming a strongly packed structure. They consist of honeycombed (cavernous) structure and they appear like dots which are slightly spherical in structure. They exhibit size range from 10 to 500 nm in diameter. They have ability to encapsulate hydrophilic, hydrophobic, and amphiphilic substances. Cubosomes have relatively simple preparation methods; they render bioactive agents with controlled and targeted release, possess lipid biodegradability, and have high internal surface area with different drug-loading modalities.

j. Nano dispersions

Most of the nanoparticles are suitable for both lipophilic and hydrophilic drug delivery. Nanodispersions are suitable for hydrophobic actives.

SNo	Delivery System	Description	Particle Diameter	Materials carried
1	Nanodispersions	Phospholipid based cellular dispersion	100-500nm	Hydrophobic actives

Table 2: Nanoparticles Delivery System

Hazardous Effects of Nano Perfumes (NP) on ecosystem

Increasing interaction of NPs with biological and chemical ecosystems has raised concerns regarding their general, occupational health and safety profiles. Although NPs have made incredible progress in the field of cosmetics, little is known about their fate in the ecosystem.

Formerly known as ‘the environmental white knight’, these particles tend to amalgamate with other noxious pollutants by adsorption.

3 Global Industry Overview

The global perfumery market reached a value of US$ 38.8 Billion in 2018. The global perfume market size was estimated at USD 32.50 billion in 2019 and is expected to reach USD 33.69 billion in 2020. The market value is projected to reach US$ 48.0 Billion by 2024, at a projected CAGR of 3.6% over period of 2019- 2024. [3]The market growth is attributed to the growing trend of personal grooming, coupled with increasing demand for luxury and exotic fragrances. Moreover, increasing consumer spending on premium and luxury fragrances due to the high-income level, along with improving living standards, is driving the global market. In recent years, perfumes have evolved into a significant business in the cosmetics and personal care industry.

Product diversification by manufacturers is also expected to expand the customer base. Product innovations based on customer needs are further augmenting the sales in the perfume market. For instance, Lauder's Jo Malone stores offer fragrance consultations so that shoppers can develop a customized product. Key players are also focusing on introducing natural fragrances in the premium category, primarily due to rising concerns over allergies and toxins in synthetic ingredients. Premium perfumes are expected to expand at the fastest CAGR of 3.9% from 2019 to 2025 owing to the growing preference for unique, handcrafted, and exotic fragrances.

Market size value in 2020	USD 33.69 billion
Revenue forecast in 2025	USD 40.9 billion
Growth Rate	CAGR of 3.9% from 2019 to 2025

Though the predictions were made before COVID, after COVID it was seen that the Fragrances and Perfumes market in the U.S. is estimated at US$11.8 Billion in the year 2020. The country currently accounts for a 27% share in the global market. China, the world second largest economy, is forecast to reach an estimated market size of US$11.3 Billion in the year 2027 trailing a CAGR of 6% through 2027. Among the other noteworthy geographic markets are Japan and Canada, each forecast to grow at 0.9% and 2.4% respectively over the 2020-2027 period. Within Europe, Germany is forecast to grow at approximately 1.6% CAGR while Rest of European market will reach US$11.3 Billion by the year 2027.

At present several new technologies are being used in the global industry for the creation of long lasting, effective, retentive fragrances with longer shelf life. These are being done with use of new delivery systems like nanotechnology, microencapsulations, microsponges, liposomes etc.

[3] IMARC Group Report on "Perfume Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019-2024"

4 Indian Industry Overview & Need for Intervention

The fragrance market in India is anticipated to reach INR 139.44 billion by 2024, expanding at a compound annual growth rate (CAGR) of ~15.93% during the period, from its 2019 value of INR 66.58 billion. India fragrance Market is growing with a CAGR of 32.71% from last five years and is projected to get more than ten times by the year 2021. The unorganized market in this industry is accounting considerable market share. Both the black and grey markets pose significant challenges to the sales of industry players in fragrances.

After COVID, sales of fragrances are expected to grow by 1% in 2020 considering the impact of COVID-19. This compares to an expected 7% rise forecast for 2020 during research conducted at the end of 2019 before the spread of COVID-19. All categories in fragrances are expected to see significantly slower growth in retail value sales at constant 2019 prices in 2020 over the previous year, as a result of the COVID-19 pandemic.

India fragrance market is divided into two segments viz. Perfume and Deodorant category. Deodorants dominate the market while perfume along with its innovations is growing fast. Fogg is leading in deodorant category followed by Park Avenue and Wild Stone.

Indian consumers became more brand conscious in 2019 although this trend has adversely impacted the growth of premium fragrances. While branding is obvious in some categories such as clothing, branding can be more challenging in premium fragrances in terms of making it visible to consumers. As a result, consumers often opt for masstige brands or competitively priced premium fragrances rather than spend much higher sums on premium brands.

Indian perfumery industry is still at its nascent stage and lot of improvement is needed in terms of the following:

- Toxic chemicals like ethanol, formaldehyde and benzaldehyde, present in most fragrance products, often cause rashes or burning sensation, and may also lead to inflammation, dryness, redness and irritation of the skin. Consumers who are aware of the side effects of these chemicals refrain from buying and using such products. As a result, sales margin of the chemical-based fragrance companies gets hampered, thereby leading to the bad light for normal Indian fragrance companies.
- The fragrance products marketed in India consist of several players who do not adhere to the quality standards set by authorities like CIRS (Chemical Inspection & Regulation Service), Drugs & Cosmetics Act, ISO (International Organization for Standardization) and GMP (Good Manufacturing Practice).
- Counterfeit fragrance products are available at much lower prices than the original ones and are hence popular among price sensitive consumers. This in turn is hindering the growth of the fragrance products market in India.
- There is no certification agency in the country where the quality of fragrances is tested and certified to be fit for use.
- Proper Lab dedicated to fragrance testing is not yet developed in the country.
- Similarly, the industry is still confined to the older technologies of blending and creating perfumes.

5 Technology Intervention

5.1 Artificial Intelligence Powered Fragrance Creation

Artificial intelligence and data-driven algorithms are heralding a new era for the fragrance industry, which is being transformed by machine learning.

5.1.1 Symrise's Philyra

What it does: Symrise's Philyra, created in partnership with IBM Research, analyzes thousands of formulas in order to identify patterns and discover innovative fragrance combinations. The system's algorithms accelerate the fragrance creation process by designing formulas that have never been seen before. This includes algorithms that learn and predict raw material substitutes and complements that can be used in a formula, appropriate dosing for a raw material based on usage patterns, 'likability' factor (whether the fragrance will be well received), and novelty of the fragrance when compared to commercially available fragrances. Philyra's data-driven approach also leverages data on fragrance families, historical data, and industry trends.

Why it's a game-changer: Philyra uses machine learning to discover whitespaces in the global fragrance market and create new formulas. Symrise's perfumers add the final touch by finetuning the creations, for example, by emphasizing a certain note or improving the long lastingness of the fragrance.

Where it's used: Philyra created two millennial fragrances that launched in 2019 for Brazilian personal care company O'Boticario.

5.1.2 Givaudan's Carto

What it does: Givaudan's Carto is an AI-powered tool that is designed to reinvent the way perfumers create, with the added benefit of accelerating perfume development. The AI program invites perfumers to imagine and create new fragrance accords using an interactive touch screen (creating their formulas differently from the traditional spreadsheet or olfactive pyramids). The program can cross-reference the fragrance house's own market research, research and development, consumer data and historical formulas. Carto also includes an instant-sampling robot that accelerates the production of fragrance trials.

Why it's a game-changer: Carto enables perfumers to experiment with creative concepts by using the playful AI interface, which is supported by an extensive data library of fragrance formulations.

Where it's used: Carto is being used in Givaudan's fragrance creative centers in all regions.

5.1.3 Scentbird's Confessions of a Rebel

What it does: When direct-to-consumer Scentbird launched new gender-fluid sub-brand Confessions of a Rebel, it used AI, consumer data and reviews to create its four initial fragrances. (Confessions of a Rebel defines itself as a 'next-gen fragrance brand, ready to push boundaries'). Scentbird leveraged over a million data points from its 300,000 subscribers to conceive the directions and fragrances. Instead of using typical fragrance categories such as

floral, woody, or citrus, Scentbird asked consumers to select their own descriptors, that included ‘fresh’, ‘clean’ and ‘sexy’.

Why it’s a game-changer: AI software gives Scentbird immediate access to patterns within its extensive subscriber data base, enabling it to create fragrances by way of user reviews, consumer preferences, and fragrance note preferences.

Where it’s used: Confession of a Rebel’s four gender-fluid fragrances, including Get A Room, Love High, About Last Night, and Almost Single, launched in mid-July.

5.1.4 Sommelier du Parfum

What it does: Sommelier du Parfum is an AI-powered fragrance app that helps users find their ideal fragrance. Algorithms analyze responses to a questionnaire, learning about users’ tastes and lifestyles in order to make recommendations from its database of over 30,000 fragrances. After users select perfumes that they want to test in-store among the app’s shortlist, nearby retail stores are identified (consisting of both large beauty retailers and independent boutiques). Fragrance information includes olfactory notes, the perfumer and fragrance’s history, and ingredients, together with a toxicity assessment.

Why it’s a game-changer: Sommelier du Parfum, as the name implies, educates consumers about the breadth of fragrances in the marketplace, and makes the selection accessible to them within a user-friendly app.

Where it’s used: Sommelier du Parfum helps consumers find their next fragrance which they can buy in 8,000 stores in the US.

5.1.5 Algorithmic Perfumery

What it does: Algorithmic Perfumery invites users to create their own personalized fragrance made by artificial intelligence. The system uses AI software and a variety of data (together with a sampling robot) to create a personalized fragrance for each person who interacts with it. Algorithmic Perfumery is refined all the time as new users continue to train the creative sensibilities of the AI system, and it adapts and learns from every exchange. Dutch founder Frederik Duerinck, who started the Netherlands-based company Scentronix, has presented Algorithmic Perfumery at film festivals and art exhibitions throughout 2019.

Why it’s a game-changer: Duerinck’s goal is to change how users interact with fragrance, and for every user to have their own unique fragrance. This includes fragrances with under-explored olfactive categories that are not typical of commercially successful fragrances.

Where it’s used: Algorithmic Perfumery has been on tour this year throughout Europe and North America.

5.1.6 Coty’s VR Experience

What it does: Coty’s fragrance-focused, multi-sensorial virtual reality experience, launched in Argentina with retailer Julieraque, is powered by AI. The immersive experience uses touch, smell, sound and sight to help consumers find their perfectly fine fragrance match. Shoppers wear a virtual reality headset and pick up a scented stone which activates a short video. Each stone is tied to a broad fragrance category, such as ‘citrus watery’, ‘floral fruity’ or ‘oriental spicy’,

as opposed to a particular perfume or brand. At the end of the video, consumers can receive up to six recommendations from eight Coty luxury brands based on their favorite fragrance concepts.

Why it's a game-changer: The VR technology can be scaled and adapted to suit a variety of markets and brands. The experience merges physical and digital worlds, and helps users navigate the world of fragrances.

Where it's used: Coty is planning on bringing the VR experience to additional markets, and tailoring the experience to specific brand universe

In a nutshell if we see these new tools help to

a) predict alternative raw material or substitutes to be used
b) human response
c) the novelty of fragrance as well as the appropriate dosing of raw material, among other components.
d) It also helps in understanding consumer preferences which in turn helps the company to focus on perfecting the final product rather than spending time searching for new fragrance combinations.

This data has been generated by a team of computer scientists who used a set of algorithms to predict the odour of different molecules based on their chemical structure. They labelled the smell with more than 19 descriptors, including "fish," "garlic," "sweet," or "burnt." They also created a massive database based on pleasantness and intensity of odour. While the immediate use of these programs was not sure, it can now find a way into the fragrance or perfume industry. New technology based on artificial intelligence could accurately predict future taste preferences among specific groups, allowing food and drink companies to get ahead of the next big trend and better target new product launches.

5.2 Nano Technology

Application of Nanotechnology in perfumery is a very important aspect to be considered seriously to grow in the industry. Currently known applications of nanotechnology in perfume production and application are predominantly based on nano-encapsulation methods:

5.2.1 Production of perfume (aroma) compounds.

Application of nanotechnology enables

- Reduction of costs of perfume compounds manufacturing,
- Manufacturing high quality ingredients,
- Manufacturing complete natural perfume compounds since they are derived from reaction catalyzed by enzymes from natural organisms,
- Compounds of low toxicity like using gold nanoparticles to replace toxic reagents that increases oxidation of aromatic primary alcohols to aldehydes,
- Manufacture of highly sensitive perfumery compounds.

5.2.2 Time-controlled and prolonged release of scents.

Nano-encapsulation (nano-delivery systems) can also help -

- improve the attributes and performance (durability, stability) of substances such as fragrances that can be negatively affected by changed conditions of the environment (light, air).
- enable more efficient (prolonged) and time-controlled release of the scents.

5.2.3 Electronic Noses

Use of nano-encapsulation procedures in development of 'nanotechnology electronic noses' (replication of human olfactory sense). It helps in

- Detection and absorption of variety of odors, which could be used in detection and absorption of unwanted or hazardous odors (e.g., carbon monoxide),
- Facilitating electronic sampling and testing of fragrance products, thus reducing the costs of fragrance and fragrance products development,
- Enabling development of artificial nose for anosmic people,
- Nano perfume ejectors are made to mix nanoparticles with perfume and / or water particles and enable sterilization of air, absorption of unpleasant and release of pleasant odors.

5.2.4 Higher retentivity of Perfumes.

Nanoparticles can be used for or Perfume encapsulates. Where in Aromatic molecules penetrate the surface of the skin by sweating, leaving small droplets on the skin that emits a unique aroma.

- Higher retentivity of fragrances and clarity of product for aesthetically pleasing formulations.
- Chitospheres: Biodegradable, enhances stability of fragrances without use of surfactants Prevents oxidation and degradation of products. Chitosan is a fully biodegradable natural polymer of marine origin.
- Cosmospheres: beads based on cellulose and lactose. They have no shell wall and disappear completely when rubbed delivering the fragrance.

5.2.5 Preparation and application of fragrance Nanocapsules:

Many times, the main active components of fragrances are chemically unstable and susceptible to deterioration and loss when the fragrance are exposed to oxygen, light and heat. Nano and micrometer size capsules with a hollow core domain and a shell can effectively protect the stability of the fragrance and control their release. The structures and properties of fragrance capsules can be tailored by choosing a variety of shell materials.

5.2.6 Use of Nano-emulsions in making Nano-perfumes:

Nano-perfumes are more fine quality Fine fragrances, having

- Long lasting effect
- Longer shelf life

- More heat and light stability
- Cost Effectiveness

The application of nano-emulsions as a novel delivery system for lipophilic materials, such as essential oils, and fragrances is one of the growing technologies. Their characteristic properties, like small droplet size with high interfacial area, transparent or semi-transparent appearance, low viscosity, and high kinetic stability, make them a perfect vehicle for fragrances, in the perfume industry. They could be a great alternative to water-based perfumes, without alcohol, and solve problems related to the oxidation and low bioavailability of fragrances with other non-alcoholic vehicles of perfumes like pomades or gels.

The nano-perfume systems can be obtained with a low-energy (Phase Inversion Composition; PIC) and with a high-energy (ultrasound, US) method. Stable systems are obtained with a fragrance composition concentration within 6–15% range. These formulations have a low viscosity and a pH suitable for the skin.

5.3 Potential Risks of Nanotechnology based Perfumes

The main concerns of using nanotechnology in perfumes as in all personal care and cosmetics products are connected to potential human health and environment hazards. Few of the major concerns are:

- Some nanoparticles can cross the natural Blood brain barrier and that they can lethally damage living cells.
- Nanoparticles can enter the human bodies through skin and inhalation. nanoparticles inhaled enter the pulmonary tract and some may travel via nasal nerves to the brain and gain access to other organs via blood.
- Potential environmental hazard. Scarce information is available regarding the possible impacts of spreading nanoparticles into the environment during the life cycle of nano-based fragrance products.
- Can cause health hazards and toxicity.

5.4 Application of AI in Fragrance Industry in India

Today if we look at the Indian Fragrance market it is still lagging in terms of quality Fragrance creation. Indian fragrance industry is still looked down upon by the global industry as lacking in quality and substance. Especially the small companies dealing with the creation of fragrance blends. This is due to the aspect that Indian business owners in this field are still not well versed in this field and lack the advanced technical knowledge in creating these products. After looking at the global data in the fragrance industry we can say that if we bring in the Artificial intelligence technologies in India then they can be used in the Indian scenario to:

a) Improve the standard of Fragrance Industry in India
b) Help in improving the quality of fragrance blends
c) Help the small and medium scale industries to upgrade themselves

d) Aid the government in creating a tool for the upliftment of fragrance sector in India.
e) Provide more employment

Hence looking at where the industry and technology is leading us India should aim at developing its own technology which will help several small perfumery companies to utilize the new program in development of the new trends in fragrances. These systems will help in generating a new breed of entrepreneurs who can start selling their own perfume blends which have been created by AI technology and will also help the shopkeepers. In fact, with the aid of AI technology Fragrance creation Kannauj and the area around it can be converted into a Tourist destination and Fragrance capital of India like Grasse is for France. As though today Kannauj and the area is known for the perfumes but still there are no real fragrances and experiences which people can take back. So, with these technologies the small shop owners selling attars can also get help and can start selling the ethnic fragrances with a modern twist, created with the help of these technologies.

The technology can be divided into two parts:

5.4.1 E nose

Use of Artificial olfaction, i.e., e-nose, plays a critical function in robotics by mimicking the human olfactory organ that can recognize different smells. The e-nose through mimicking the olfactory receptors with the programmed algorithm of the artificial neural network helps in the recognition of the pattern of odors (i.e., their chemical profiles).

Advantages of E Nose:

- Allows for monitoring of the shelf life of natural perfumery herbs by sensing the aromatic VOCs due to post-harvesting, respiration, fermentation, and phenolic oxidation.
- Detection of off notes in a perfume blend.
- Detection of perfumery compounds in a perfume blend.
- Detection of impact of factors on the stability of fragrance blends.
- Detection of Quality of Raw materials
  - o Identification of raw materials used in perfumery.
  - o Detection of adulteration in perfumery raw materials.

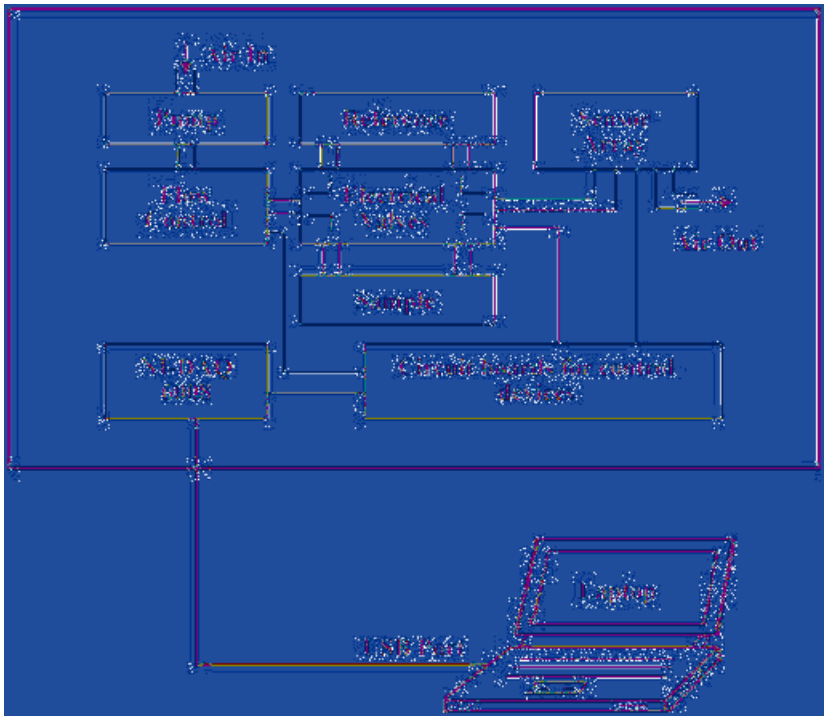

Figure 2: E-Nose Components

5.4.2 Artificial intelligence Technology

The AI technology can be used to analyze the current data inferences, patterns and learnings and use them to create new blends of flavours and fragrances which can then be used by the entrepreneurs, Retailers and other small and medium companies to create new quality flavour and fragrances as per the choice of current consumers. The AI system can be created by using Python.

Advantages of AI in Fragrance Industry:

- Creation of new modern blends.
- Will help the entrepreneur in creating world class fragrances.
- Can Create Personalized fragrance and flavours for companies.
- Can help Kannauj to become the fragrance and flavour capital again.
- Can help several retailers to give the consumers exact fragrance and flavour of their choice.
- Cost effective as will help in saving Raw material and energy cost earlier used in trial and errors.
- Will bring in revenue for the government as companies can utilize the capabilities to create unique, personalized, quality fragrance blends.

This AI system will be designed to learn and predict the following attributes:

- Possible alternative raw material complements and substitutes for a formula.
- Appropriate ratios of raw materials (based on usage patterns).
- Market success (based on consumer liking).
- Novelty of system-generated flavor/fragrance formulas, as measured by a derived distance function in the space of possible flavors or fragrances.
- A definition of what it means to be a particular product.

Once the AI system is installed FFDC can use it to generate revenues by doing projects for the industry in creation of new and unique personalized fragrances and do quality analysis of various manufactured raw materials in India as well as agricultural produce for aroma mission can be evaluated for the quality before distillation.

5.5 Aromatherapy, AI and Nanotechnology

Aromatherapy is both an Art and a Science. It has for ages been considered as a holistic form of therapy. Though aromatherapy cannot make large medical claims, as practicing aroma therapists do not have complete scientific claims validation for their treatments and hence this treatment has gone into questionable areas. Hence it is the prevalent notion that Aromatherapy lacks in modern technological proof that can establish its efficacy.

Aromatherapy is the use of essential oils for therapeutic or medical purposes (Buckle, 2003). It acts upon the holistic principles of awakening and strengthening energies and promoting self-healing. Buchbauer defined aromatherapy as – “therapeutic uses of fragrances to cure, mitigate or prevent diseases, infections and indispositions by means of inhalation.”

The main component of aroma therapy is essential oils.

Aromatherapy is generally used for treatment of common problems like headache, cough, cold, sleep related issues, stress, anxiety etc. Advanced practitioners are using aromatherapy in treating psychological as well as various physiological issues.

Routes of administration: Aromatherapy is generally administered in three ways to a patient:

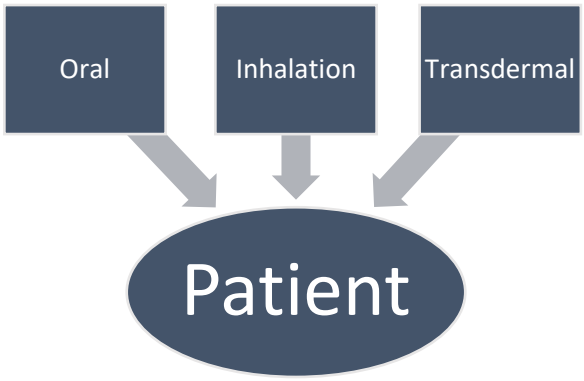

Figure 3: Aromatherapy Administration Methods

a. **Oral route:** The essential oils are generally administered orally in the form of oils or as seasoning in consumable products. The oils are Bitter tasting and may irritate mucosal lining. This mode of application is suitable only under supervision of experienced practitioners, as regular ingestion over a long period of time may lead to hepatotoxicity. Oils are often formulated into capsules and then consumed orally.
b. **Transdermal route**: Lipid solubility of essential oils allows for better penetration in the skin. Easy penetration generally happens maximum behind ears, eyelids, inside the wrist followed by soles, palms, forehead, scalp, armpits, and the least in legs, buttocks, trunk and abdomen. The oils are often applied by rubbing or massaging. The oils are generally incorporated in carrier oils, gels or creams and then massaged on the skin.
c. **Inhalation:** This is the most common and effective route of administration and is regarded as “true aromatherapy”. The incidence of adverse effects using this method is very rare. Methods of administration include spraying on cloth and using an aroma diffuser, among others.

Essential oils: The main component of aroma therapy is essential oils, also sometimes referred to as volatile oils. Essential oils are aromatic oils extracted naturally from plant and animal sources and are used for treatments. Essential oils play a key role in plant metabolism and are also used in plants for communication. They are used by plants to attract certain beneficial insects and repel others. Essential oils allow plants to send and receive signals. Chemical communication requires specific signals that can be clearly recognized and interpreted. These chemicals are mostly in combinations, (like acetal and ester) or in enantiomeric forms e.g. α bisabolol has two enantiomeric forms - (+) α bisabolol and (-) α bisabolol.

Essential oils contain two main groups according to their biochemical origin

1. Terpenes & Higher Monologues

2. Phenylpropane derivatives (cinnamic acid & aldehyde)

Oils whose main constituents belong to the same group exhibit similar effects, but again each oil exhibits different characteristics apart from these similar effects. Terpenes & Higher homologues (other molecules based on terpenes) - e.g. geraniol (terpinen alcohol-antiseptic and tonic), Farnesol (Sesquiterpene alcohol) etc.

Essential oils contain mostly mono and sesquiterpenes. Mono terpenes are smaller molecules and their high oil content gives more clarity, less viscosity and more volatility e.g. eucalyptus oil. Sesquiterpenes have larger molecular weight and make the oil coloured (yellow/dark yellow/brown) and more viscous e.g. sandalwood, patchouli. Phenylpropane derivatives (cinnamic acid & aldehyde) - are by-products of the amino acid metabolism. These break down to form substances like anethol (antispasmodic, stabilizing effects), eugenol (stimulant, irritant & antiseptic property) etc.

Aromatherapy mechanism: Two basic mechanisms are offered to explain the effect of aromatherapy.

1. First is the influence of the aroma in the brain, especially the limbic system through the olfactory system.
2. The other is the direct pharmacological effects of essential oils.

The efficacy of the aromatherapy remains unproven. Once the oils are circulating in the blood, they are carried to the target organ, where they exert a therapeutic effect on the specific tissues. e.g. Juniper oil targets the urinary tract and kidneys, with secondary effects on the Digestive, Respiratory and Reproductive Systems. Chamomile Oil targets the Nervous System via which it exerts a broad effect on body Systems, like Digestive Tract etc.

Examples of therapies applied and absorbed through the skin include stress relieving therapies and motion sickness patches.

The global fragrance industry has shown affirmation that essential oils can affect the mood, boost productivity, help in restful sleep, alter psychological conditions of human beings and modify human behaviour on a regular and subconscious level.

Artificial intelligence can be used in aromatherapy for:

1. Evaluating and diagnosing the anxiety levels and problems in patients.
2. Evaluating the chemical constituents of essential oils.
3. Finding out the potential antimicrobial ability of essential oils.
4. Finding out the purity and level of adulteration by E-Nose and further finding out the ability of an oil in treating a certain health condition.
5. AI can be used in creating a shopping app for the customers to help them in selecting the correct oil or combinations of oils for the treatment of particular issue they are facing.

Application of Nanotechnology in aromatherapy for the benefit of FFDC

Nanotechnology based applications can be used in aromatherapy to create:

a. Nanoparticles which will help in keeping the essential oils stable in a formulation.
b. Nanoemulsions can be created with aromatherapy oils to get better benefits.
c. Retailers can create nanocapsules and store pure essential oils for longer periods.
d. Nanotechnology can be used to retain the smell and chemical constituents throughout the shelf life of the product.
e. Nanotechnology can be used by FFDC to help the farmers in keeping the freshness. of essential oils which will help in increasing the value of essential oils as well as increasing the export possibilities for the oil.

6 Technology Adoption

Nanotechnology can be incorporated at Technology Centres by creating the following:

6.1 Nano emulsion Fragrances

Nano-emulsion system is a transparent/translucent solution that containing two immiscible liquids consisting of a fine dispersion of active component structured in nano lipid droplets stabilized by surfactant, which known as micelles or micellar nanoparticles. Through formation of micellar nanoparticles in nano-emulsion, the oil phase plays a major role as component that essential to solubilize with lipophilic active component in cosmetic formulation. The amount of oil composition may vary from 2 to 20% w/w. Typically, the oil phase consists of the lipophilic cosmetic's bioactive ingredient such as essential oil, or antioxidant agents and carrier oil. The usage of carrier oil is usually to easily facilitate the micellar formation or enhance nano-emulsion system stability. Non-ionic surfactant is the most preferable due to their lesser toxicity and irritant compared to ionic (anionic and cationic) surfactant. Nano emulsions are created by High-Energy Emulsification Technique. Huge interfacial areas for nanoscale emulsion formation can be formed by implement high-energy technique by which larger droplets are ruptured into smaller droplets due to the mechanical energy, supplies fluid stresses to successful reducing interfacial tension between oil and aqueous phases and resulted into larger total droplets per volume formation. Generally, two steps are involved to form smaller micelles by using high energy method;

a) final formation of smaller droplets from deformation and disruption of macro size molecules,
b) surfactant adsorption at their interface through aqueous medium to promote steric stabilization.

Four groups are categorized as typical process of high-energy emulsification method:

1. High shear stirring using rotor/stator system,
2. High-pressure homogenization,
3. Ultrasonication,
4. Microfluidizer process.

Microfluidizer offers more advantages compared to high-pressure homogenizer in terms of short period nano-emulsion formation due to direct emulsification technique by injecting dispersed phase into aqueous phase and form nano-emulsion immediately without any pre-emulsification step. Through this process, the two immiscible liquids, oil and water components flow through microchannels under high pressure of 2000 psi, combined and processed in inline homogenizer to form nano-emulsion. However, even though micro-fluidization is the most successful process to form narrower micelles droplets in nano-emulsion system than other emulsification techniques, it has some limitations such as high manufacturing cost, long emulsification period and channels clogged by solid particles, which possesses to re-coalescence phenomenon to happen resulting into larger micelles droplets formation.

6.2 Nano particle Raw materials

Creation of Nano particle raw materials for the perfume industry will significantly increase the retentivity of the fragrances. Micellar nanoparticles (MNP) technology offers robust and versatile delivery system to incorporate with wide range of lipophilic components. Micellar nanotechnology promotes smaller nanoparticles, better encapsulation efficiency, and affordable production cost

Oil in water emulsion system is one of micellar nanoparticles formation techniques which can be used to make Nano perfumes. These nano perfumes and nano raw material particles can be sold by TCs to various perfume companies for increasing the retentivity, shelf life and longevity of fine fragrances and deodorants.

7 Technology Transformation Roadmap

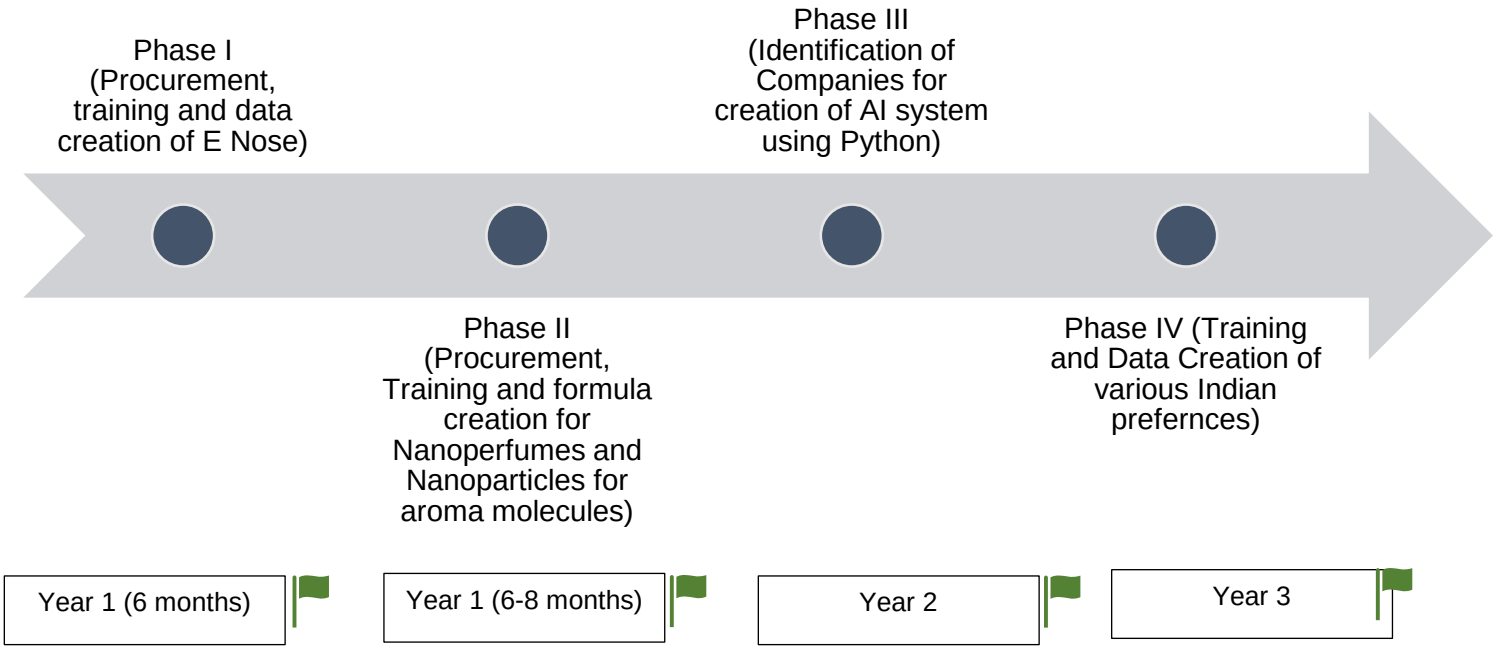

Figure 4: Technology Transformation Roadmap

Phase 1:

Procurement, Training and Data creation of E Nose

Step A: The various steps in this phase will be:

a) Brainstorming, Survey for selection of vendors for E Nose
b) Writeup specification for E Nose: It should have the following sensors

Gas sensor types	Sensitivity	Selectivity	Speed	Cost	Size
Chemoresistor	High	Medium	Fast	Low	Small
FET	High	Medium	Fast	Medium	Small
SSES	High	Good	Fast	Low	Large
QCM	High	Poor	Medium	High	Medium

Table 3: Sensors for the E-nose

c) Procurement and readiness of physical infrastructure

Step B: The various steps in this phase will be:

a) SOP creation for use of E Nose
b) Training of staff for E Nose

c) Creation of SOP for various applications of E Nose

Phase 2: The various steps in this are Procurement, Training and method creation for Nano-perfumes and Nanoparticles for aroma molecules

a) Brainstorming, Survey for selection of vendors for MicroFluidizers and Nano encapsulation machines
b) SOP creation for Microfluidizers and Nano encapsulation machine
c) Training of staff on the machines
d) Creation of molecules and new blends using the machines

Phase 3: The various steps in this phase will be:

a) Brainstorming, Evaluation and survey of existing AI systems
b) Survey for selection of vendors for AI System using Python
c) Writeup specification for AI System using Python
d) Procurement of Python AI System

Phase 4: The various steps in this phase will be:

a) Secure Networks, Platform creation
b) Loading of AI system
c) SOP creation for using the AI system
d) Training of staff for AI System
e) Loading of data created by E Nose in AI system
f) Appropriate Data sharing platform creation
g) Plan implementation, Plan with mitigation and plan for observed challenges

7.1 Adoption Framework for Technology Centre

The process of upgradation to these advanced technologies will face a challenge specially with respect to the economic consideration, awareness level and implementation challenges. The above transformation roadmaps can show path to transform Technology Centres training and service providing capabilities with enablement of emerging technologies. But, the real challenge that TCs will face lies in the procurement of the machines and the adoption of the technology and its further transgression in the fragrance industry.

To achieve successful technology adoption appropriate experienced personnel are required and identification of organizations with immediate need of upgradation. As these technologies are new and emerging, a pilot level implementation is always recommended, so that all the risks associated with implementation and change are identified and a mitigation plan can be prepared.

Before a pilot level program implementation, few trained personnel should be exposed to the international companies to observe the use and implementation of the program. Then the AI program development vendors should train the person in their premises and then the pilot implementation should be done. Once the pilot implementation is completed and organizations feel confident on these technologies, a full-scale implementation can be taken up.

At FFDC Kannauj, these technologies can be adopted in its critical area of operations such as Fragrance creation, testing and training areas. With the help of above transformation roadmap platforms can be selected to track these critical parameters on critical technology aspect. Thus, the dashboards, visualizations created by these emerging technology and platforms will help FFDC to make itself more displaceable and remunerative system.

Approximate Cost involved:

Machines	Cost	AMC
Microfluidizers	Rs 35,00000	Rs 10,00000
Nanoencapsulation	Rs 30,00000	Rs 8,00000

Table 4: Approximate Cost Involved - Nanotechnology

Adaptation of system for Industry:

The AI technology can be used in the following ways for benefit of FFDC and MSMEs. All these technologies also have a special relevance to scenarios such as today where physical training is not possible due to COVID-19 can be easily overcome with this technology.

Application Area	Application/Use	Benefits	Implementation Priority
Raw material Creation Services for Industry	— Creation of new raw materials for industry — Creation of new raw material for performance enhancement of fragrances — Creation of new blends for fragrances	— Blends can be sold for a price to the industry willing to buy — Time and energy saving activity — Customization culture can be brought in the industry	Priority 1
Research Service for industry	— New raw material creation based on research — New research data creation for industry	— Help to generate more funds — Increase the technology sound reputation of FFDC — New avenues for growth will be opened	Priority 2
Testing Facility	— Creation of New generation Testing facility — More MSMEs can use this to test the quality of perfumes and get a certificate issued by FFDC — Farmers can test their crops grown in Aroma Mission and find the quality of the yield	— Quality parameters for the industry can be set up — Creation of Final certifying agency for quality of FFDC for India — Loss of quality crops can be avoided, and quality ingredients can be created by the farmers	Priority 1

Table 5: Adoption Framework

8 Conclusion & Way Forward

This activity of technology enhancement will revolutionize raw material and testing scenarios not only in India but around the world. It will highlight the fact that India is no less in quality, specification creation, certification, technology and can be on the same or more advanced platform as compared to France and other European countries in Fragrance sector. Small changes in quality raw material usage which is at present unavailable in the market can pave way for creating higher quality fragrances in the industry. The ability to embrace by the Industry and use the opportunities that will rapidly present themselves will be the key to success in the new global market.

As a way forward, Technology Centres can initiate to adopt these technologies at a pilot level. These above implementation plan can help TCs in implementing emerging technologies, visualization of the consumer requirements and creation of new age quality and cost-effective raw materials and testing facilities for the industry and farmers. These implementations will not only increase the confidence of industry in TCs but will also help to become the quality evaluation and certifying body in the industry.

Once this is done, TCs can identify broader areas for implementation. They can initiate capacity building of its staff and MSMEs on these technologies to bridge the gap in understanding, fill the voids of technical know-how and suggest customized roadmap based on sop's created in this technology roadmap. TCs can initiate testing facilities for MSMEs and farmers with these advanced technologies which will also enhance employability. They can further use this technology to conduct Research and create a complete data base for the Indian industry which in turn will help in employment and creation of revenue for the Government and the Technology Centre.

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