Nanoemulsion for Pakinson's Disease

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***Abstract*—Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by the degeneration of dopaminergic neurons in the brain, which results in the development of symptoms such as tremors, rigidity, and bradykinesia. Traditional treatments involve symptom relief, typically through either an increase in dopamine levels or its mimetic action, but issues such as low bioavailability, dose variability, and failure to cross the BBB limit the efficacy of conventional treatments. The unique properties of nanoemulsions-which include an increase in the solubility, bioavailability, and stability of hydrophobic drugs with droplet sizes below 100 nm-make them very promising candidates for drug delivery in PD by possibly bypassing the BBB. Preparation techniques such as high-pressure homogenization, ultrasonication, and phase inversion methods in nanoemulsion-based delivery systems for PD will be reviewed here. It also points out the benefits of nanoemulsions, such as targeted delivery, sustained release, and better stability. Applications in PD management are discussed, which include drugs such as levodopa, ropinirole, and resveratrol encapsulated in nanoemulsions to improve therapeutic outcomes. Future prospects emphasize the possibility of nanoemulsions in revolutionizing neurological disease treatments by overcoming conventional drug delivery limitations and improving patient outcomes.**

***Index Terms*—Dopaminergic neurons, High-pressure homogenization, Neurodegenerative disorder, Neurological disease treatments, Phase inversion methods,**

I. INTRODUCTION

Parkinson's disease is considered the second most common neurodegenerative disease in the world. In PD, dopaminergic neurons in the substantia nigra region of the brain degenerate and dopamine levels drop in the striatum, causing symptoms such as postural in stability, tremors, rigidity and bradykinesia [1]. Nano emulsions are colloidal dispersions consisting of oil, water and an emulsifier. They are increasingly being studied as potential drug delivery systems due to their ability to improve drug solubility, stability, bioavailability and targeting Nano emulsion drug delivery systems are excellent tools for delivering and improving the bioavailability of hydrophobic drugs and bioactive ingredients in the blood. Most drugs are hydrophobic (lipophilic) in nature, which causes weakness and biological problems [2,3]. Although Nano emulsions have shown promise for transporting drugs across various biological barriers, including the blood-brain barrier (BBB), their specific use in the treatment of Parkinson's disease (PD) is an area of ongoing research. Parkinson's disease is a neurodegenerative disease characterized by the progressive loss of dopaminergic neurons in the brain, especially in the substantia nigra region. Current treatments for Parkinson's disease mainly focus on alleviating symptoms such as motor deficits and tremors with drugs that increase dopamine levels or mimic its effects in the brain.

Such formulations of drugs and food components have low oral bioavailability, uncertain absorption profiles, dose variability, high intra- and inter-individual variability, and greater potential for dietary effects. Thus, these drugs and bioactive food components show poor therapeutic efficacy [4]. Nanotechnology approaches have several advantages over conventional systems for CNS diseases. These include designing various agents at the nanoscale to bypass the blood-brain barrier (BBB) to target specific cell types or signalling systems that respond to endogenous stimuli, i.e. pH, enzymes or act as carriers for gene transfer [5]. The brain is protected from the circulating blood by a tight barrier the blood-brain barrier (BBB), which prevents the free diffusion process [6].

Nanoemulsion contain droplets smaller than 100 nm in size which is the basic requirement for facilitating the transport of drugs through the intranasal route

thus, there is a rising interest in the field of nanoemulsion for the intranasal route [7]. It limits penetration of substrate depending on a few parameters which include poor lipophilic nature, large sized molecule, and peculiarity for a various transport system which are ATP dependent. Brain disorders related discovery of drug is facing a setback due to vacant pipeline of drugs and innumerable failures of potential new drugs in clinical trials. Among Central Nervous System (CNS) diseases, the neuro-degenerative ones are the most exigent which are characterized by a gradual decrease in neurological function which is age related, accompanied by neuronal death [8].

II. FORMULATION TECHNIQUES OF NANOEMULSION

The techniques used in the preparation of nano emulsion drug delivery systems are diverse and there is considerable overlap. We have classified various methods to prepare nano emulsion drug delivery systems according to energy requirement, nature of phase inversion and self-emulsification.

A. High energy methods:

High energy methods are widely used in the preparation of nanoemulsion [9]. High mechanical energy is used to generate strong breaking forces that break large droplets into nano-sized droplets and produce nanoemulsion with high kinetic energy. Disturbing forces are generated by mechanical devices such as sonicator, microfluidizers, and high-pressure homogenizers [10]. By using high-energy methods, we can achieve better control of particle size through formulation formulation selection. High energy methods also control emulsion stability, rheology and colour. For food ingredients, high-energy nanoemulsion preparation methods have the advantage of reducing the risk of deterioration and deactivation of food components without affecting food safety and nutritional and sensory properties [11]. High energy methods include the following methods.

1. High pressure homogenization

High pressure homogenizers produce high energy and produce a constant current to produce the smallest particle. Therefore, high-pressure homogenizers are most often used to prepare nanoemulsion. High-pressure homogenizers are used to generate very disruptive forces that form nanoemulsion with very small particle sizes (down to 1 nm) [12]. The crude emulsion is then passed through a small orifice under high pressure (500-5000 psi) (Figure 1). This process combines several forces such as strong turbulence, hydraulic shear and cavitation to produce nanoemulsion with very small droplets.

The particle size of nanoemulsion produced by high-pressure homogenizers depends on the composition of the sample, the type of homogenizer, and the operating conditions of the homogenizer, such as energy intensity, time, and temperature (increasing the intensity of homogenizer reduces the number of droplets in the size of nanoemulsion. In certain cases, for example, when biopolymers are used as an emulsifier, intensive homogenization can lead to the particle size of the resulting nanoemulsion increase, so small molecular surfactants should be used as emulsifiers in high pressure homogenizers, because they are more effective than biopolymer in the production of nanoemulsion. High-pressure homogenization is widely used to form nanoemulsion of food, pharmaceutical and biotechnological ingredients [14].

Table.1 Various active ingredient, loaded in nanoemulsion using different techniques

Techniques	Active ingredients
High-pressure homogenization	Quercetin, pepper mint oil, carotenoid, peanut milk, capsaicin, primaquine, and paclitaxel.
Micro fluidization	Essential oil, D-limonene, fish oil, curcumin, and ß-carotene.
Ultrasonicator	Cinnamon oil eucalyptus oil, bovine serum, albumin capsaicin, aspirin, and artemether.
Phase inversion composition method	Hexadecane and oleic acid mixture lidocaine and hydrogenated polyisobutene.
Phase inversion temperature method	Fisetin, isohexadecane, mineral oil, cinnamon oil, and lemon oil.

Emulsion inversion point method	Curcumin and vitamin E
Self-nanoemulsification method	Glimepiride, ibuprofen, valsartan, and glibenclamide

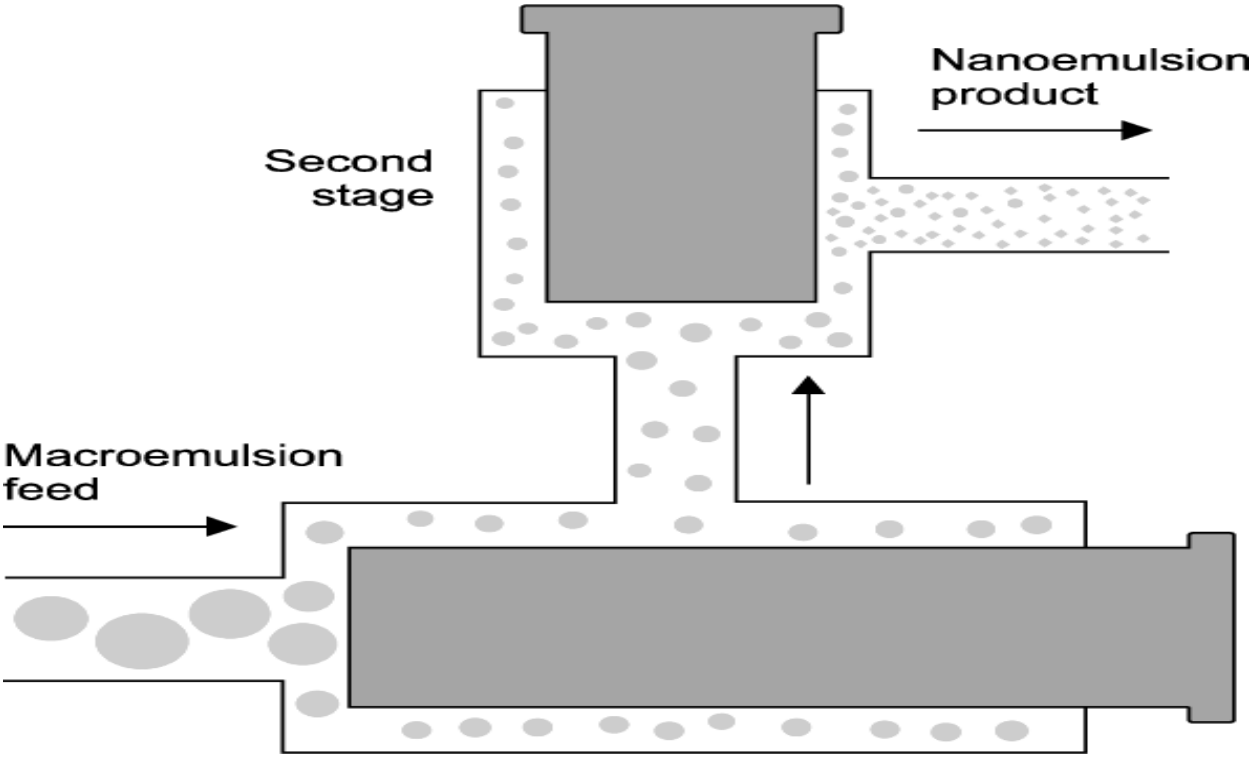

Fig.1 High pressure homogenization techniques [13].

2. Microfluidization

Microfluidization is a mixing technique at the micro scale level that uses a device called a micro fluidizer. In micro fluidization, fluids are forced through micro channels under high pressure (500-20,000 psi). Micro channels are typically micro-sized channels that allow for micro-sized mixing [15]. The macro emulsion phases (water and oil phases) are mixed together and then passed through a micro fluidizer. The macro emulsion is moved through the micro channels under high pressure towards the interaction chamber. In the interaction chamber, two macro emulsion streams collide with each other at high speed. This collision produces forces such as shear, cavitation and impact that produce stable nanoemulsion.

Microfluidizers produce narrower and smaller nanoemulsion particle size distributions of than homogenizers [17]. Also, microfluidizers produce stable nanoemulsion at low surfactant concentrations. Microfluidization methods have been used to produce food ingredient nanoemulsion. Microfluidization techniques produce food grade nanoemulsion with uniform droplet size distributions and greater stabilities.

3. Ultra Sonication

Ultrasound is superior to other high-energy methods in terms of application and cleaning [9]. In ultrasonic emulsions, the ultrasonic waves provide cavitation forces that break the macroemulsion into a nanoemulsion. This method uses ultrasound devices consisting of a transducer that emits ultrasound waves. By varying the ultrasonic energy input and time, we can achieve the desired particle size and stability of the nanoemulsion. In ultrasonic emulsification, physical shearing is achieved primarily by an acoustic cavitation process. Cavitation is a phenomenon where microbubbles form and grow due to pressure fluctuations of an acoustic wave, which then collapse (Fig.3). The collapse of the microbubbles creates intense turbulence that leads to the formation of nanosized droplets [18].

Irradiating the oil and water system with ultrasound causes cavitation forces and provides additional

energy to new interface formations, resulting in the formation of nanosized emulsion droplets, using ultra sonication, nanoemulsion can be produced without surfactants [20]. A recent study showed that the effectiveness of ultrasonic emulsification depends on the intensity, time and nature of the surfactant. Ultrasonic processing has been widely used to prepare nanoemulsion of pharmaceutical and food ingredients. Food-grade ultrasonic nanoemulsion shows better stability and smaller droplet size and requires less energy than other high-energy methods.

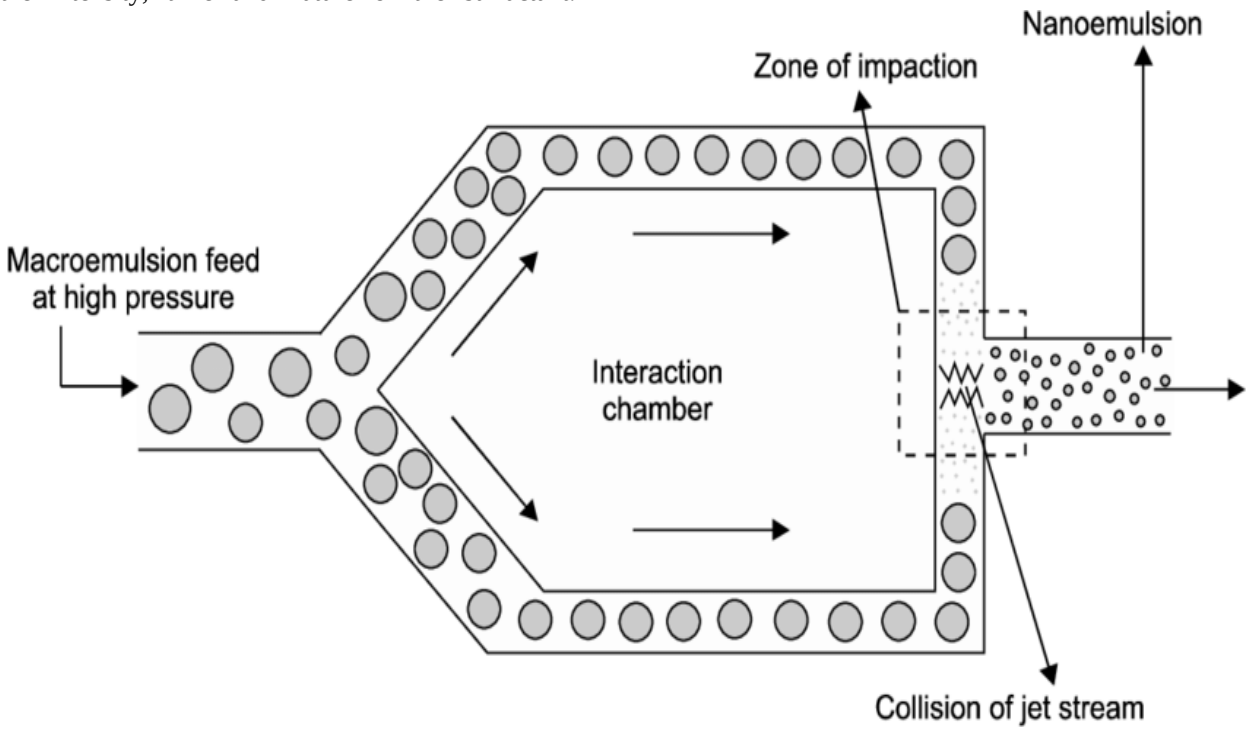

Fig.2 Microfluidization technique [16]

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B. Low energy method

These methods require little energy to produce nanoemulsion systems. Low-energy emulsification methods are more energy-efficient because they exploit the internal chemical energy of the systems and require only light agitation to produce nanoemulsions. Low-energy emulsification methods typically include phase reversal emulsion and self-

emulsification. In general, low-energy methods are not considered for the preparation of food-grade nanoemulsions because they require a high concentration of surfactant, which negatively affects the taste and safety of the food composition [21].

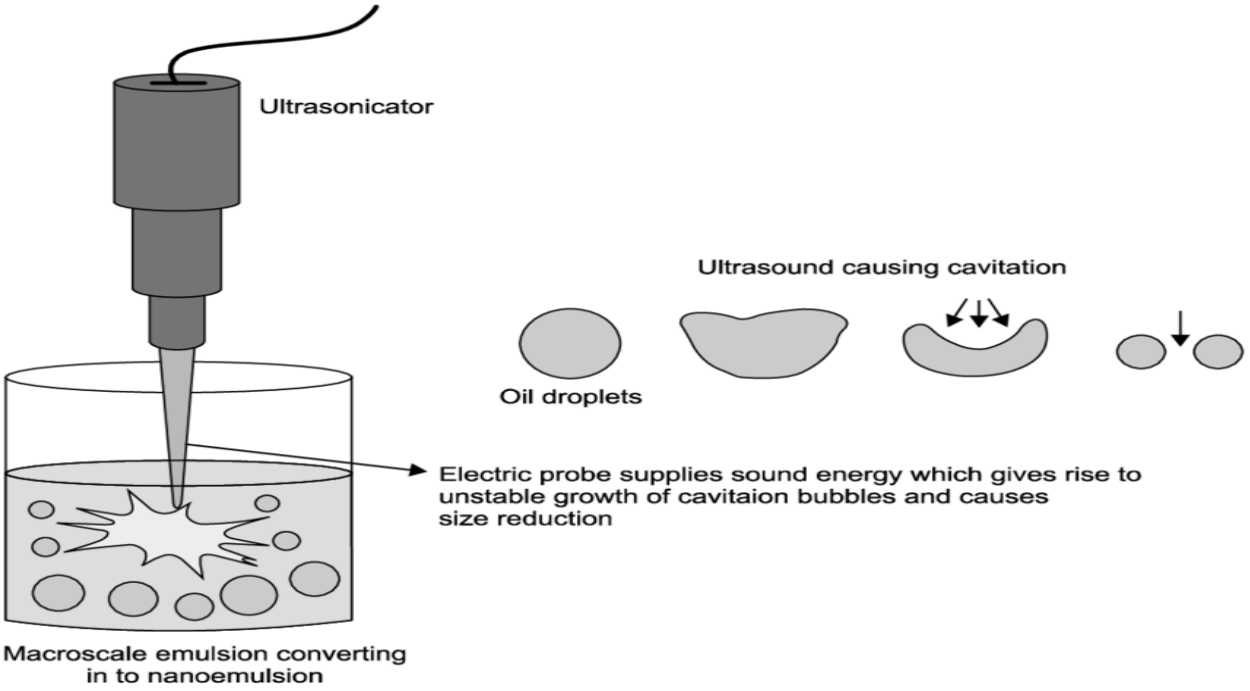

Fig.3 Ultra sonication techniques [19].

1. Phase inversion emulsification method

In this method, the spontaneous curvature of the surfactant causes a phase change during the emulsification process. Changes in the spontaneous curvature of the surfactant occur with changes in parameters such as temperature, composition, etc. (Fig.4)[22]. There are two types of phase inversion emulsification methods: TPI methods, which include PIT and PICC, and CPI methods, which include EIP (Fig. 4).

Transition phase inversion occurs due to the spontaneous curvature or affinity change of the surfactant due to changes in parameters such as temperature and composition [22]. However, CPI occurs when the dispersed phase is continuously added until the droplets of the dispersed phase aggregate with each other to form bicontinuous/laminar structural phases. Catastrophe means a sudden change in the behavior of a system due to a change in circumstances. For catastrophic phase inversion to occur, it is important that the surfactant is mostly in the dispersed phase, where the coalescence rate is high, leading to rapid phase inversion. During transient phase inversion, the spontaneous curvature or surfactant affinity changes, while during catastrophic phase inversion, the spontaneous curvature or surfactant affinity does not change.

2. Phase inversion temperature (PIT)

In the PIT method, the spontaneous curvature of the surfactant is reversed due to temperature change. Nonionic surfactants, such as polyethoxylated surfactants, undergo dehydration of the POE groups of the polyethoxylated surfactant, making it more lipophilic and causing changes in surfactant curvature. Thus, phase inversion occurs and a nanoemulsion is formed. In this method, oil, water, and non-ionic surfactants are mixed at room temperature to form oil- in-water (O/W) emulsions Then, as the temperature gradually increases, dehydration of the POE groups of the surfactant occurs, which makes the surfactant more lipophilic and the surfactant begins to show a higher affinity for the oil phase. This causes a phase inversion from the original oil- water emulsion to a water-in-oil (W/O) nanoemulsion by intermediate liquid crystals or bicontinuous structures (e.g. lamellar phase). At hydrophilic-lipophilic equilibrium (HLB) (mid-

temperature) temperatures, the non-ionic surfactant has zero curvature and has similar affinity for the aqueous and oil phases [24]. Effective phase inversion requires rapid cooling or heating of the HLB (to obtain O/W or W/O emulsions, respectively). Rapid cooling or heating produces kinetically stable nano emulsions.

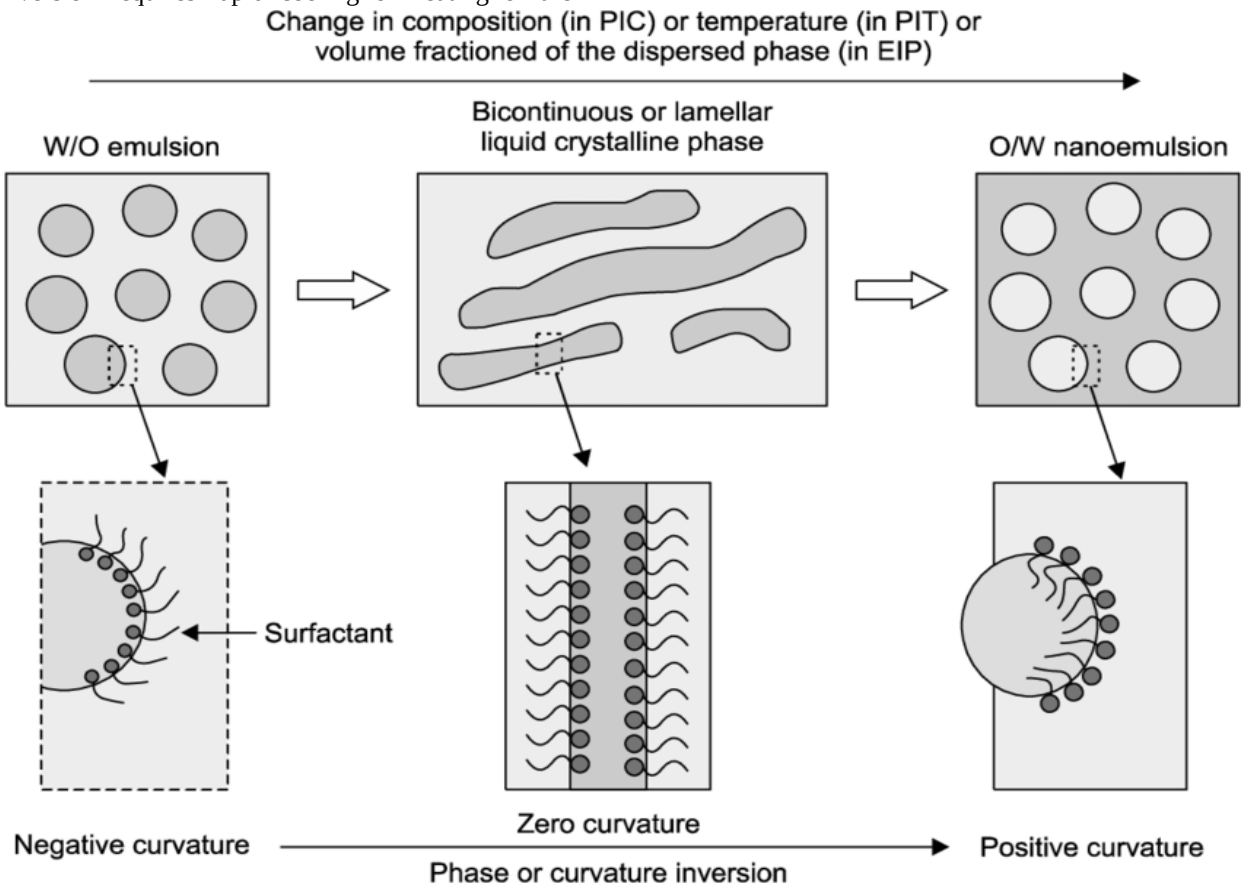

Fig.4 O/W, oil-in-water emulsion; W/O, water-in-oil emulsion. Phase inversion emulsification techniques. PIC, phase inversion composition; PIT, phase inversion temperature; EIP, emulsion inversion point [23].

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4. Phase Inversion Composition (PIC)

The composition of the phase version, or PIC method, is similar to the PIT method. However, in PIC, phase inversion is achieved by changing the composition of the system rather than the temperature of the system [25]. In PIC, one of the components, such as water, is added to the mixture, and an oil-surfactant or oil is

added to the water-surfactant mixture. Non-ionic surfactants of the POE type are often used in the PIC method to prepare nanoemulsion, although other types can also be used. When water is slowly added to the oil phase and as the volume of the water fraction increases, hydration of the POE chain of the surfactant occurs.

The hydrophilic-lipophilic properties of the aqueous phase of the surfactant are balanced, and the spontaneous curvature of the surfactant becomes zero, as in the PIT method at the HLB temperature. During this transition, a bicontinuous or lamellar structure is formed. As more water is added, the transition composition is crossed and the surfactant layer

structures with zero curvature change to those with high positive curvature. This change in curvature causes phase inversion and causes the formation of nanosized droplets. Thus, changing the composition of the system causes a phase reversal [26]. Also, other formulation parameters such as salt addition and pH changes cause the formation of nanosized emulsion droplets by inversion of the transition phase [25].

5. Emulsion inversion point

In the EIP method, the phase inversion occurs through CPI mechanisms. Catastrophic phase inversion is induced by changing the fraction of the dispersed phase rather than the properties of the surfactant [27]. When an aqueous phase is added to the oil-surfactant mixture, the system begins to function as a W/O nanoemulsion. If, with continued stirring, more and more water is added above the critical water content, the water droplets merge and the phase inversion point is reached; this leads to the formation of bicontinuous or lamellar structures. Further dilution with water causes a phase inversion from a water/water to an oil/water system via an intermediate continuous micro emulsion [26, 27].

The droplet sizes of the nanoemulsion formed depend on process variables such as water addition rate and stirring rate. For a catastrophic phase inversion to occur, the surfactant should be mostly in the dispersed phase, so that the coalescence rate is high and the phase inversion occurs rapidly. Low molecular weight surfactants can be used for catastrophic phase inversion. These surfactants are able to stabilize both water/water emulsions. Initially, in a catastrophic phase inversion, the surfactant is mostly in the dispersed phase, so it behaves like an abnormal emulsion (unstable emulsion) that does not obey Bancroft's rules. According to Bancroft's rules, in a stable emulsion (normal emulsion), the emulsifier should be mainly in the continuous phase [28]. Therefore, a catastrophic phase inversion occurs in the abnormal emulsion, forming a more stable normal emulsion.

6. Self-nanoemulsification method

In the self-emulsification method, nanoemulsion formation is achieved without changing the spontaneous curvature of the surfactant. Surfactant and/or cosolvent molecules rapidly diffuse from the dispersed phase to the continuous phase, causing turbulence and nanosized emulsion droplets [23]. The self-emulsification method is also called the spontaneous emulsification method. SNEDDS is based on the self-emulsification phenomenon and contains more hydrophilic surfactants or co-surfactants (co-solvents) and a lower lipid content. SNEDDS can be defined as an isotropic mixture of oil, surfactant, cosurfactant and drug. When this mixture is diluted with aqueous solutions in vivo, it forms a fine and optically clear O/W nanoemulsion aided by gentle agitation due to gastric and intestinal digestive movements (Fig.5) [29].

The two most commonly reported mechanisms of SNEDDS nanoemulsion formation are the diffusion of a hydrophilic cosolvent or surfactant from the organic phase to the aqueous phase [31] and the formation of a negative free energy nanoemulsion at a transient negative or very low interface, SNEDDS are also the most popular and promising means of delivering hydrophobic drugs with low bioavailability [32]. SNEDDS have also been used to deliver bioactive food components [33].

III. STABILITY OF NANOEMULSION SYSTEM

During storage, the nanoemulsion may become cloudy or the nanoemulsion phases may separate due to instability mechanisms such as flotation, sedimentation, coalescence, and Ostwald ripening [33]. The destabilization kinetics of the nanoemulsion system is very slow (several months), so that the nanoemulsion systems are kinetically stable [34]. Nanoemulsion systems produce smaller droplet sizes than conventional macroemulsions; thus, Brownian

motion effects are much more dominant than gravitational forces and have greater gravitational differential stability. Flocculation and coalescence occur due to attractive forces between droplets, which are usually very small in nanosized emulsion systems. Thus, the nanoemulsion shows much better stability towards flotation and coalescence [35]. Ostwald ripening is another nanoemulsion instability mechanism that often occurs in food-grade nanoemulsion containing essential oil and short-chain triglycerides. The milk-based nanoemulsion is relatively stable during Ostwald ripening due to the insoluble long-chain triglyceride oils. Ostwald repining can be avoided by using a more hydrophobic oil during manufacture [33].

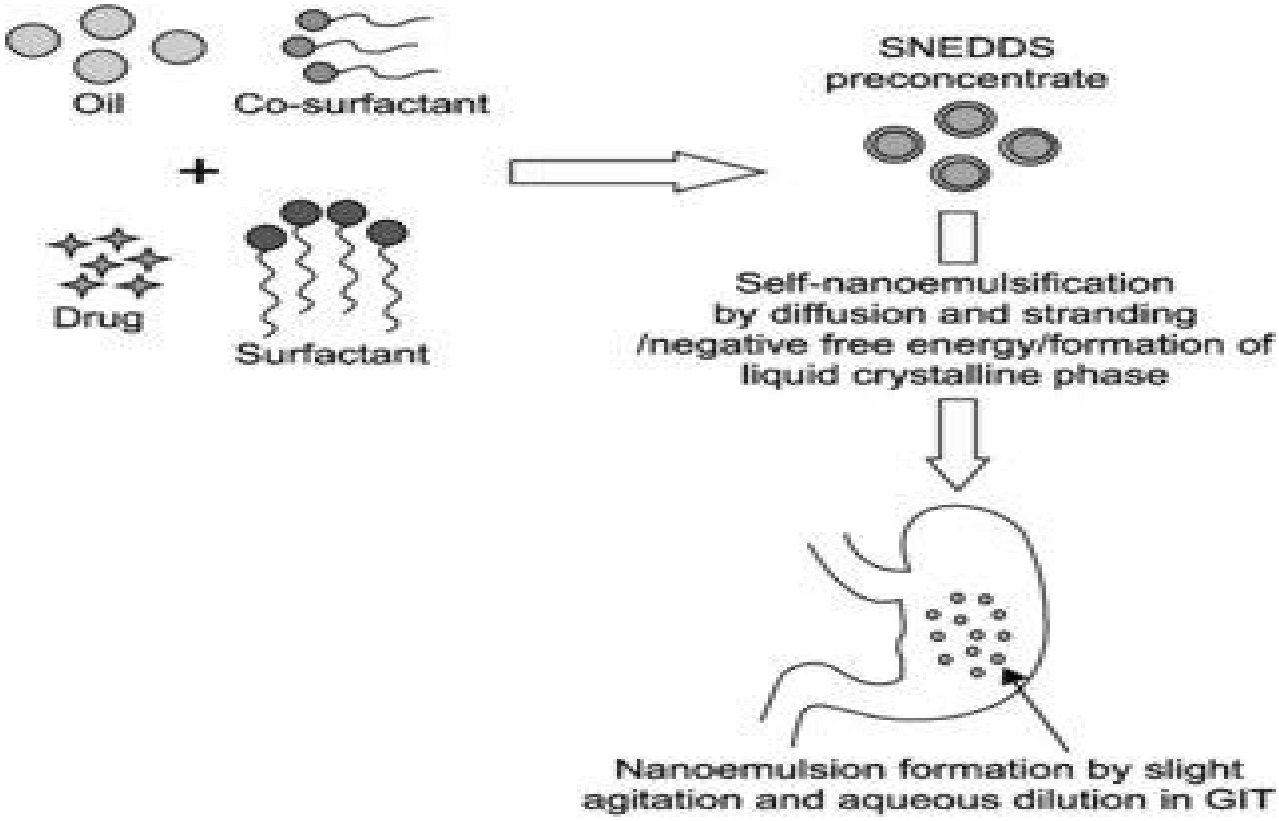

Fig.5 Self-nanoemulsification techniques. SNEDDS, self-nanoemulsifying drug delivery system; GIT, gastrointestinal tract [30].

IV. CONVENTIONAL FORMULATION PARKINSONS DISEASE

Conventional preparations used to treat Parkinson's disease usually contain drugs that aim to relieve symptoms by either increasing dopamine levels or mimicking its effects in the brain. The main classes of drugs used to treat Parkinson's disease include.

1. Levodopa (L-DOPA): Levodopa is the most effective and most commonly prescribed medication for Parkinson's disease. It is a precursor to dopamine that crosses the blood-brain barrier and is converted to dopamine in the brain. Levodopa helps restore dopamine levels, which improves motor symptoms such as tremors, stiffness, and bradykinesia [36].

2. Dopamine Agonists: These drugs mimic the effects of dopamine in the brain by binding to dopamine receptors. Dopamine agonists are often used as monotherapy or as an adjunct to levodopa. They can help reduce motor fluctuations and dyskinesia associated with long-term use of levodopa [37].

3. Monoamine Oxidase-B (MAO-B) Inhibitors: MAO-B inhibitors increase dopamine levels in the brain by blocking the monoamine oxidase B enzyme that breaks down dopamine. These drugs can be used as monotherapy or as a complement to levodopa in the early stage of Parkinson's disease [38].

4. Catechol-O-Methyltransferase (COMT) Inhibitors COMT inhibitors prolong the duration of the effects of levodopa by inhibiting the catechol-O-methyltransferase enzyme that metabolizes levodopa. It is often used with levodopa to reduce motor disturbances [39].
5. Anticholinergic Drugs This medication helps with tremors by blocking the action of acetylcholine, a neurotransmitter involved in motor control. Anticholinergics are often used in young patients with Parkinson's disease who have severe tremors [40].
6. Amantadine: Amantadine can relieve dyskinesia in a short period of time and also has an antiparkinsonian effect by increasing the release of dopamine and blocking glutamate receptors. The selection of drugs and the requirements depend
on the location of the disease, the main symptoms, of age, etc. It depends on many factors. It covers the patient's condition, the presence of diseases and the individual response to treatment. Current formulations of these medications include tablets, capsules, orally disintegrating tablets, solid-release formulations, and liquid formulations for people with swallowing difficulties. In addition to pharmacological interventions, non-medical treatments such as physical therapy, occupational therapy, and speech therapy. Medicine is available, deep brain stimulation (DBS) surgery may be recommended to control Parkinson's disease symptoms and improve quality of life [41].

V. NANOTECHNOLOGY OF BLOOD BRAIN BARRIER

Nanotechnology has great potential to overcome the blood-brain barrier (BBB), a highly selective membrane that strictly controls the flow of substances from the blood to the brain. The BBB is a major challenge for drug delivery to the brain, especially for the treatment of neurological diseases such as Parkinson's disease, Alzheimer's disease, and brain tumours [5].

A. Several nanotechnology-based approaches have been explored to enhance drug delivery across the BBB
1. Nanoparticles Nanoparticles, including liposomes, polymeric nanoparticles, dendrimers, and solid lipid nanoparticles, can be engineered to absorb and transport drugs across the BBB. These nanoparticles can use various mechanisms to enhance BBB penetration, such as receptor-mediated transcytosis, adsorption-mediated transcytosis, and passive diffusion through BBB breakdown [42].

2. Surface Modification**:** Nanoparticles can be surface modified with ligands and antibodies that target receptors or receptors expressed on BBB endothelial cells. By incorporating these active ingredients into nanoparticles, researchers can improve their targeting of BBB receptors, which can improve drug delivery to the brain and reduce external side effects [43].
3. Transporter-mediated transport: Certain nanoparticles can mimic the endogenous transport mechanisms used by essential nutrients to cross the BBB. For example, nanoparticles can be designed to mimic the structure of glucose or amino acids that are transported to the brain by specific carrier proteins. Using these carrier-mediated transport systems, nanoparticles can facilitate the transport of drugs into the brain parenchyma [44].
4. Focused ultrasound: Nanoparticles can be combined with focused ultrasound techniques that temporarily disrupt the BBB and improve drug permeability. Focused ultrasound generates mechanical forces that temporarily open tight junctions between endothelial cells, allowing nanoparticles to penetrate the brain parenchyma. This approach, known as focused ultrasound-mediated BBB disruption, has shown promise in preclinical studies for improved drug delivery [45].
5. Cell-penetrating peptides: Nanoparticles can be functionalized with cell-penetrating peptides (CPPs) that facilitate their entry into the endothelial cells lining the BBB. CPPs can enhance nanoparticle transport across the BBB by promoting transcytosis- or endocytosis- mediated uptake into brain endothelial cells [46].
6. Exosome-based delivery: Exosomes, nanosized vesicles secreted by cells, have emerged as promising carriers for the transport of therapeutic cargo across the BBB. Exosomes can naturally cross biological barriers, such as the BBB, and can be loaded with drugs or nucleic acids for targeted delivery to the brain.
Although nanotechnology-based approaches offer

exciting opportunities to improve drug delivery to the brain, several challenges remain, including the use of nanoparticles for size, to optimize surface properties, biocompatibility and scalability in clinical translation. In addition, the safety and long-term effects on the central nervous system of nanotechnology drug delivery systems must be thoroughly evaluated in preclinical and clinical studies [47].

B**.** Applications of Nano Emulsion

Nanoemulsion have attracted considerable interest in several fields, including pharmaceuticals. cosmetics, food, and agriculture, due to their unique properties and potential applications. Some of the most important properties and applications of nanoemulsion are,

1. Improved solubility: Nanoemulsion can improve the solubility of poorly water-soluble compounds, making them suitable for the delivery of hydrophobic drugs or active ingredients [48].
2. Improved bioavailability: The small droplet size of nanoemulsion increases drug surface available for absorption, which can improve the bioavailability of encapsulated compounds [48]
3. Targeted Delivery: Nanoemulsion can be designed to target specific tissues or cells by modifying the surface properties of the droplets or containing target ligands. For e.g Intranasal administration is non-invasive, user-friendly and needle-free and does not require trained personnel. Even self-medication is possible, resulting in patient acceptance of the possibility

of protein and peptide delivery through this route. The administered drug reaches the BBB, bypassing the central nervous system directly, where the drug rarely enters the degradation environment, and hepatic metabolism thus prolongs its residence time at the site of action [49].

4. Sustained/Controlled Release: Nanoemulsion can be designed for continuous or controlled release of encapsulated compounds, which provides a long-lasting therapeutic effect and reduces administration frequency [50].
5. Better stability: Nanoemulsion have better physical and chemical stability in comparison to conventional emulsions, which can degrade over time be prone to aggregation or phase separation [51].
6. Cosmetic and personal care applications**:** Nanoemulsion are widely used in cosmetics and personal care products to deliver active ingredients, increase product stability, and improve display properties [52].
7. Food and beverage industry: Nanoemulsion are widely used in food and personal care. Products and beverage industries to encapsulate flavour, nutrients, vitamins, and bioactive compounds and improve product texture and appearance [53].

List Of Various New Emulsion for Parkinson's Disease

Sr No.	Drug	Method	Outcome	Ref.
1.	Resveratrol	Spontaneous emulsification method	Higher concentration of the drug in the brain following intranasal administration of the optimized nanoemulsion.	[54]
2.	Bromocriptine	Confocal laser scanning microscopy (CLSM)	Oxidative stress by employing intranasal delivery of Bromocriptine Mesylate (BRM)	[55]
3.	Glutathione	Confocal laser scanning microscopy (CLSM)	The antioxidant activity of nanoemulsion was increased after intranasal delivery.	[55]
4.	Ropinirole	Aqueous titration followed by a high-pressure homogenization method.	Mucoadhesive and thermodynamically stable nano-ropinirole was developed by aqueous titration technique.	[56]
5.	Levodopa	Palm-Based Nanoemulsion System Containing Levodopa	High stability of the Levodopa-loaded nanoemulsion was due to the stabilizing effect of lecithin and Chromophore EL	[57]

6.	Entacapone	Ultrasonication and optimization of parameters such as high-speed mixing time, surfactant choice, and sonication time	Enhancing the solubility and dissolution rate of Entacapone could lead to heightened bioavailability and therapeutic efficacy.	[58]
7.	Rotigotine	Rotigotine mucoadhesive nanoemulsion (RMNE) for intranasal delivery	Administering rotigotine as mucoadhesive nanoemulsion through IN route may be an effective alternative to solve the problem of rotigotine oral delivery system	[59]

VI. CONCLUSION

Nanoemulsion are a fruitful field in science. This allows for better absorption and delivery of drugs, making it a good choice for the treatment of neurological diseases such as Parkinson's disease. The use of nanoemulsion can significantly improve the effectiveness of some anti- Parkinson drugs, such as levodopa, curcumin, etc. In this article, we review nanocarriers and methods that enhance the efficacy of available neuroprotective drugs. The paper also sheds light on the future prospects of nanoemulsion for the management of Parkinson's disease.

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