CODEN [USA]: IAJPBB ISSN : 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

SJIF Impact Factor: 7.187

https://doi.org/10.5281/zenodo.5917467

Available online at: http://www.iajps.com *Review Article*

A COMPLETE REVIEW ON NANOEMULSION

Priyanka Shukla[*1], Sadhana Singh[2]

[*1] Assistant Professor, Lucknow Model College of Pharmacy, Lucknow

[2] Lecturer, Lucknow Model College of Pharmacy, Lucknow

Article Received: December 2021 **Accepted:** December 2021 **Published:** January 2022

Abstract:

Nanoemulsions are colloidal dispersion systems that are thermodynamically stable, composed of two immiscible liquids mixed along with emulsifying agents (surfactants and co-surfactants) to form a single phase. Nanoemulsions have extensively been investigated as drug delivery systems. Nanoemulsions are also clear, transparent. Nanoemulsion are also known as mini-emulsion, ultrafine emulsion, and submicron emulsion. These are the oil-in-water type of emulsions with the average droplet size ranging from 5 nm to 100 nm. Nanoemulsions are thermodynamically stable transparent or translucent dispersions of oil and water stabilized by an interfacial film of surfactant and co-surfactant molecules having a droplet size of less than 100 nm. This review aims to provide consolidated information regarding various formulation and characterization techniques developed for nanoemulsions. Various characterization techniques for nanoemulsion include determination of particle size, photon correlation spectroscopy, differential scanning calorimetry, phase behavior study and transmission electron microscopy etc. Nanoemulsions are further evaluated by studying in vitro drug release, stability, viscosity, refractive index, and pH etc.

Corresponding author:

Priyanka Shukla,
Assistant Professor,
Lucknow Model College of Pharmacy,
Lucknow

QR code

Please cite this article in press Priyanka Shukla et al, ***A Complete Review On Nanoemulsion.,*** *Indo Am. J. P. Sci, 2022; 09(01).*

INTRODUCTION:

Nano-emulsions are a new type of emulsion which can be defined as an emulsion with uniform and extremely small droplet sizes, typically in the range of 20–200 nm. Due to their small droplet size, it looks like transparent or translucent. It is also kinetically stable against sedimentation or creaming for a long period of time because of their small droplet size. The use of nanoemulsions in oral dosage forms achieve promising results in higher targeting efficacy of drug, and also increases the drug bioavailability, enhanced permeability and therapeutic functions. [1]

The term "Nanoemulsion" refers to a thermodynamically stable isotropically clear dispersion of two immiscible liquids, such as oil and water, stabilized by an interfacial film of surfactant molecules. [2] A nanoemulsion is considered to be a thermodynamically or kinetically stable liquid dispersion of an oil phase and a water phase, in combination with a surfactant.

Types of nanoemulsion

1. Water-in-oil nanoemulsions: Nanoemulsions in which water droplets are dispersed in continuous oily phase.[3]

2. Oil-in-water nanoemulsions: Nanoemulsions in which oil droplets are dispersed in continuous aqueous phase.[4]

3. Bi-continuous nanoemulsions: Nanoemulsions in which micro domains of oil and water are inter-dispersed within the system i.e. O/W/O and W/O/W. [5]

Advantages of nanoemulsion:

1. Nanoemulsions are thermodynamically stable system and the stability allows self-emulsification of the system.
2. Nanoemulsion has a transparent and fluidity property which improves the patient compliance and ease of administration due to the absence of any thickening agent and colloidal particles. [6]
3. Drug absorption variability can be decreased. [7]
4. Nanoemulsions can deliver both type of drugs i.e. hydrophilic and lipophilic.
5. Nanoemulsion also enhances permeability of drug into skin. [8]

Disadvantages of nanoemulsion:

1. For stabilizing the nano-droplets, it requires large concentration of surfactant and co- surfactant.[9]
2. Limited solubilizing capacity for high-melting substances.
3. The surfactant must be nontoxic for using pharmaceutical applications. [10]
5. Lack of understanding of the mechanism of production of submicron droplets and the role of surfactants and cosurfactants. [11]

Limitations of nanoemulsion: Some limitations of nanoemulsion are as follows:

a. The manufacturing of nanoemulsion formulation is an expensive process because of their nano size requirement.
b. Reduction of droplets is very difficult as it required a special kind of instruments and process methods. Stability of nanoemulsion is quite unacceptable and creates a big problem during the storage of formulation for the longer time unacceptability of nanoemulsion formulations.
c. Ostwald ripening is the main factor associated with less availability of surfactant and cosurfactant required for the manufacturing of nanoemulsion. [12]

Components of Nanoemulsion:

Main three components of Nanoemulsions are:
1. Oil
2. Surfactant/Co surfactant
3. Aqueous phase. [13]

Nanoemulsions are colloidal dispersions which is composed of an oil phase, aqueous phase, surfactant and cosurfactants in an appropriate ratio. Unlike coarse emulsions micronized with external energy, nanoemulsions are based on low interfacial tension. This is achieved by adding cosurfactants, which leads to spontaneous formation of a thermodynamically stable nanoemulsion. The droplet size in the dispersed phase is very small, usually below 140 nm in diameter, which makes the nanoemulsions transparent liquids. [14]

Method of preparation of nanoemulsion:

A. Phase inversion method: In phase transition method, The adequate phase transitions is obtained by changing the composition of oil and aqueous phase at constant temperature or also by changing the temperature at constant composition. This method is based on principle of the changes of solubility of polyoxyethylene type surfactant with temperature. This surfactant becomes lipophilic as increase in temperature because of dehydration of polymer chain. At low temperature, the surfactant monolayer has a great positive spontaneous curvature forming oil swollen micellar solution phase. [15]

B. Solvent Displacement Method: The solvent displacement method has been adopted from the nano-precipitation method used for polymeric nanoparticles. In this method, the oily phase is dissolved in water-miscible organic solvents, and [16] organic phase is poured into the aqueous phase containing a surfactant to yield a spontaneous nanoemulsion by rapid diffusion of the organic solvent. After that organic solvent is removed from the nanoemulsion by use of vacuum evaporation method. Spontaneous nano-emulsification has also been produced when the solution of organic solvents containing a small percentage of oil is poured into the aqueous phase without any surfactant. [17]

C. Spontaneous Emulsification: This method consists of three main steps:
a. First of all, prepare homogeneous organic solution which is composed of oil and lipophilic surfactant in water miscible solvent and hydrophilic surfactant. [18]
b. The organic phase is then injected in the aqueous phase under magnetic stirring, the o/w emulsion was formed.
c. After that, the water-miscible solvent is removed by evaporation under reduced pressure. [19]

D. Sonication method: Sonication method is another best and easy way to prepare nanoemulsion. In this method, the droplet size of conventional emulsion or even microemulsion are reduced with the help of sonication mechanism. This method is not suitable for large sample, it is applicable only for laboratory or small-scale purpose. Equipement used in this method is ultra- sonicator. [20]

E. High Pressure Homogenization: This technique makes use of high-pressure homogenizer/piston to produce nanoemulsion of extremely low particle size (up to 1nm). In a high-pressure homogenizer, the dispersion of two liquids (oily phase and aqueous phase) is achieved by forcing their mixture through a small inlet orifice at very high pressure (500 to 5000 psi), which subjects the product to intense turbulence and hydraulic shear resulting in extremely fine particles of emulsion. [21] Homogenizers of varying design are available for lab scale production of nanoemulsions. This technique has great efficiency, the only disadvantage being high energy consumption and increase in temperature of emulsion during processing. [22]

F. Self-emulsification methods: This method prepare nanoemulsion at room temperature without any use of organic solvent and heat. In this method, small droplet size of 50nm can be generated by step wise addition of water into solution of surfactant in oil, with gentle stirring and at constant temperature. [23]

Characterization of nanoemulsion:

A. Differential scanning calorimetry (DSC): DSC provides information on the interactions of different components and polarization microscopy using crossed polarizers is employed to confirm isotropicity of the formulation. [24]

B. Particle size analysis: The Particle Size is measured by Particle Size Analyzer. It is important to measure the Particle Size and necessary to understand how they affect the products. [25] Nanoemulsion formulations are analyzed for particle size and size distribution by the light scattering method. The nanoemulsions were diluted suitably with deionized distilled water so as to obtain the average count rate of 50-500 kcps. Particle size analysis was carried out at a scattering angle of 90° and a temperature of 25°C. [26]

C. pH measurement: Digital pH meter is used to determine the pH of the nanoemulsion. [27]

D. Transmission electron microscopy: It is a very simple method to determine the size, number, weight and structure (morphology characteristic). O/w nanoemulsion is stain with uranyl acetate and placed on a grid, coated with monolayer polymer, then water is evaporated and observation is done using TEM. [28]

E. Refractive index: This study is done by using an abbes refractometer. [29]

F. Phase behavior study: Phase behavior study is necessary for those nanoemulsions that are prepared by phase inversion Temperature and self emulsification method and used to determine the phase of nanoemulsion, dispersibility and for the optimization of ingredients (surfactant, oil phase and aqueous phase). This study is done by placing the different ingredients of nanoemulsion in glass ampoules at varying the concentration. Then all ingredients are thoroughly homogenized at a certain temperature for a time until equilibrium. An isotropic phase can be identified by polarized light is used to identify an isotropic phase [30].

G. Photon correlation spectroscopy: The mean particle size and the size distribution of the nanoemulsions were determined by photon correlation spectroscopy. The prepared nanoemulsions were diluted 40 times with suitable aqueous phase for the measurement of droplet size. The average diameter and poly-dispersity index of prepared samples were measured by photon correlation spectroscopy (Nano ZS90, Malvern

Instruments, and U.K). The measurements were performed at 25˚ C using a He-Ne laser [31].

H. Viscosity determination: Viscosity of nanoemulsion is determine by using suitable viscometer such as Brook field viscometer. [32]

I. Flocculation and creaming: Flocculation consists of the joining together of globules to form large clumps or floccules, which rise or settle in the emulsion more rapidly than the individual globules. The rising up or settling down of dispersed globules to give a concentrated layer is known as creaming. Thus flocculation leads to creaming. Flocculation and creaming is determined by visual inspection of stored sample. [33]

J. In-vitro drug release: The drug release kinetics studied using a modified method. A glass cup whose cross-sectional area is 1.5 cm^2 is filled with 0.2ml nanoemulsion, and covered it with a cellophane membrane, sealed with adhesive tape, and inverted under the surface of 30 ml of simulated Vaginal fluid of pH 7.4 at 37°C ± 0.5°C in USP XXIII Type I Dissolution Test Apparatus with a speed of 300 rpm. [34] 1ml of sample is withdrawn at specified time intervals and immediately replaced with fresh dissolution medium. The drug content in the withdrawn samples is determines by U.V. spectroscopy. [35].

Applications of nanoemulsion:

Nanoemulsions could be and have been applied in various aspects of drug delivery including: cosmetics and transdermal delivery of drug, cancer therapy, vaccine delivery, prophylactic in bio-terrorism attack, non-toxic disinfectant cleaner, cell culture technology, formulations for improved oral delivery of poorly soluble drug, ocular and otic drug delivery, intranasal drug delivery, parenteral drug delivery and pulmonary delivery of drugs.[36]

Nanoemulsions in Cell Culture Technology: Cell cultures are used for in vitro assays or to produce biological compounds, such as antibodies or recombinant proteins. To optimize cell growth, the culture medium can be supplemented with a number of defined molecules or with blood serum. The advantages of using nanoemulsions in cell culture technology are better uptake of oil- soluble supplements in cell cultures; improve growth and vitality of cultured cells, and allowance of toxicity studies of oil-soluble drugs in cell culture. [37]

Nanoemulsion in Topical Application: Nanoemulsion is a promising alternative to increase drug delivery system penetration and targeting poorly soluble drugs, by increasing its absorption through the skin, better retention time of drug in the target area and eventually result in less side effects and it improves the permeation of drug through skin. So that it gives effective results in topical application. [38]

Nanoemulsions in food industry: Nanoemulsions can be used in the food industry to design smart foods with ingredients that are otherwise difficult to incorporate due to low-water solubility; an example is b-carotene, a pigment responsible for color in vegetables like carrots possessing important health benefits. Nanoemulsions in the food industry have explored the preparation and stability of flavored nanoemulsions using low energy methods.

Nanoemulsions as building blocks: Nanoemulsions can be used as building blocks for the preparation of more complex materials through exploitation of their small size and high surface area which enable easy decoration of a liquid–liquid surface with functional moieties such as designer macromolecules. [39]

Drug and gene delivery: In the field of topical and transdermal drug and gene delivery, there are several studies based on the enhancement of skin permeation and extended release for hydrophilic and lipophilic drugs, application of nanoemulsions for topical gene delivery, and photodynamic therapy.

Cosmetic Applications: Nanoemulsions have attracted considerable attention for application in personal hair products. They were found useful for an optimized dispersion on skin and controlled delivery of cosmetics. They are easily valued in skin care because of their good sensorial properties and their biophysical properties especially hydrating power. [40]

Parenteral Delivery: Parenteral administration (especially via the intravenous route) of drugs with limited solubility is a major problem in industry because of the extremely low amount of drug actually delivered to a targeted site. [41] Nanoemulsion formulations have distinct advantages over microemulsion systems when delivered parentrally because of the fine particle Nanoemulsion is cleared more slowly than the coarse particle emulsion and, therefore, have a longer residence time in the body. O/W and W/O Nanoemulsion both can be used for parenteral delivery. [42]

Nanoemulsion in Mucosal Vaccine: Nanoemulsions are utilized to deliver either recombinant proteins or inactivated organisms to a mucosal surface to produce an immune response. The 1st application, an influenza vaccine and an HIV vaccine, can proceed to clinical trials.[43] The nanoemulsion needs proteins applied to the mucosal surface to be adjuvant and it facilitates uptake by antigen-presenting cells. Additional research is ongoing to complete verify concept in animal trials for other vaccines including Hepatitis B and anthrax20 Mice and guinea pigs intranasally immunized by the application of recombinant HIV gp120 antigen mixed in nanoemulsion which demonstrated robust serum anti-gp120 IgG, as well as bronchial, vaginal, and serum anti- gp120 IgA in mice.[44]

As Antimicrobial: Antimicrobial nanoemulsions are o/w droplets, ranges from 200 to 600 nm. They are composed of oil and water and are stabilized by alcohol and surfactants. Nanoemulsion has a broad-spectrum activity against bacteria (e.g. E. coil, Salmonella s, S. aureus), enveloped viruses (e.g. HIV, Herpes simplex), fungi (e.g. Candida, Dermatophytes), and spores (e.g. anthrax). Nanoemulsion can attain a level of topical antimicrobial activity that has only been previously achieved by systemic antibiotics. [45]

Nanoemulsion in the treatment of various other disease condition: Pharmos (US-based company) has developed nanoemulsion topical diclofenac cream as potential treatment for osteoarthritis pain. A topical application of nanotechnology has already demonstrated excellent targeted delivery of lipophilic drug to muscle and joints in animal model. Nanoemulsion also used to treat many more diseases. [46]

CONCLUSION:

Nanoemulsions are widely used in pharmaceutical systems. Nanoemulsion formulation offers several advantages such as delivery of drugs, biological or diagnostic agents. The most important application of nanoemulsion is for masking the disagreeable taste of oily liquids. Nanoemulsion may also protect the drugs, which are susceptible to hydrolysis and oxidation. Recently, Nanoemulsions are receiving great attention as drug carrier for improving the delivery of neutron capture therapy agents, various anticancer drugs and pharmaceutical ingredients. Now - a - days, many studies have focused on using nanoemulsion for transdermal drug delivery. The Nanoemulsion formulations which are formulated is found to be transparent because its particle size in nm and these formulations contains oil, surfactants, and co-surfactants. Overall all nanoemulsion formulation may be considered as effective, safe and with increased bioavailability. It is expected that further research and development will be carried out in the future regarding nanoemulsion. From this review we can conclude that nanoemulsion offers different routes to deliver the formulation. It offers multiple advantages for less soluble drugs. It is also effective in targeted and controlled delivery of the drug.

REFERENCES:

1. Chaudhri Nirvesh, Prajapati S.K., Soni C. Girish; Self nanoemulsion: Advance form of drug delivery system; World journal of pharmacy and pharmaceutical sciences, 2014, vol 3,issue 10, pp. 410-436.
2. Yadav A. Sheela, Singh Dinesh, Poddar SushilKumar; Influence of components of nanoemulsion system for transdermal drug delivery of nimodipine; Asian J Pharm Clin Res, 2012, Vol 5, Issue 3, pp. 209-214.
3. Singh Vishal, Kumar Hari SL; Nanoemulsification: A novel targetted drue delivery tool; Journal of Drug Delivery & Therapeutics , 2012, vol 2, issue 4, pp. 40-45.
4. Kumar Sunil; Role of nanoemulsion in pharmaceutical science- A review; Asian Journal of Research in Pharmaceutical Sciences and Biotechnology, 2014, vol 2,issue 1,pp. 1-15.
5. Oyelaja O. B., Dare E. O., Katare D. P. and Oladoyinbo F. O.; Nanoemulsion: A promising and novel nanotherapeutic vehicle for transdermal drug delivery; International journal of pharmaceutical science and research, 2020; Vol. 11, issue 6, pp. 2636-2648.
6. Bangia Khanna Jyoti, Om Hari; Nanoemulsions : A versatile drug delivery tool; International journal of pharmaceutical science and research, 2015, vol 6, issue 4, pp. 1363-1372.
7. Bhatt Aarti, Bhist Punit, Tyagi Satyanand; Novel drug delivery system-Nanoemulsion: A recent review; Journal of Drug Discovery and Therapeutics, 2013,vol 1; issue 3; pp. 27- 35.
8. Savardekar Pranita , Bajaj Amrita; Nanoemulsion: A review; International journal of research in pharmacy and chemistry, 2016,vol 6, issue 2,pp. 312-322.
9. Thakur Nishi, Garg Garima, Sharma P.K. , Kumar Nitin; Nanoemulsions: A Review on Various Pharmaceutical Application; Global Journal of Pharmacology, 2012, vol 6, issue 3,pp. 222-225.
10. Sharma Navneet; Preparation and Optimization of Nanoemulsions for targeting Drug Delivery; Int. J. Drug Dev. & Res., 2013, vol 5, issue 4,pp. 37-48.
11. Mohammad S Sahid, A Chowdeswari; A review on Nanoemulsion. Scandinavian journal of

pharmaceutical science and research, 2014,vol 1,issue 1,pp. 6-9.
12. Mangale M.R. , Pathak S.S., Mor B.A.; anoemulsion: A pharmaceutical overview; Int. J. Pharm. Sci. Rev. Res,2015 , vol 33, issue 1,pp. 244-252.
13. Sharma Surbhi, Sarangdevot Kumkum; Nanoemulsion for cosmetic; IJARPB, 2012, Vol. 2, issue 3, pp. 408-415.
14. Kanwale Nitin P., Dtta Gavali; Nanoemulsion :A new system for drug delivery; World journal of pharmaceutical research,2015, vol 4, issue 11, pp. 310-326.
15. Ajay Thakur, Walia Manpreet Kaur, Kumar Hari SL; Nanoemulsion enhancement of bioavailability of poorly soluble drugs: A review; Pharmacophore , 2013 , vol 4, issue 1, pp. 15- 25.
16. Anthony A. Attama, Charles lovely; Current state of nanoemulsion in drug delivery; Journal of biomaterials and nano-biotechnology, 2011, vol. 2, pp. 626-639.
17. Sokolov Yu.V.; Nanoemulsion as prospective drug delivery system; News of pharmacy, 2014,vol 1, issue 77, pp. 21-25.
18. Jatin Garg, Kumar Praveen; Emerging trends in nanoemulsion design and therapeutics: A review; Asian journal of pharmaceutical sciences and clinical research, 2014, vol. 2, issue 3, pp. 1-16.
19. Bhosale Rajendra Rohit; Nanoemulsion: A Review on Novel Profusion in Advanced Drug Delivery; Indian Journal of Pharmaceutical and Biological Research , 2014,vol 2, issue 1, pp. 122-127.
20. Sharma Nitin, Bansal Mayank; Nanoemulsion: A new concept of delivery system; Chronicles of Young Scientists, 2010, vol 1, issue 2, pp. 2-6.
21. Rajalakshmi R., Mahesh K., Kumar C.K. Ashok; A critical review on nanoemulsion; International Journal of Innovative Drug Discovery,2011, vol 1,issue 1,pp. 1-8.
22. Setya Sonal, Talegaonkar Sushama; Nanoemulsion: Formulation methods and stability aspects; World journal of pharmacy and pharmaceutical sciences, 2014, vol. 3, issue 2, pp. 2214-2228.
23. Joy Jincy, Krishnakumar K, John Anish, Dineshkumar B; Nanoemulsion in pharmaceuticals: A review; Current Research in Drug Targeting ,2015, vol 5, issue1, pp. 1-4.
24. Reddy Kumar ankit B., Debnath Subhashis; Nanoemulsion a novel approach for lipophilic drugs- A review; Asian Journal of pharmaceutical research, 2013 , vol 3,issue 2,pp. 84-92.
25. Selvi P. P.; Formulation and evaluation of aspirin nanoemulsion; Indian Journal of Science, 2016, vol. 23, issue 79, pp. 245-252.
26. Tiwari S. B., Shenoy D.B., Amiji M.M.; Nanoemulsion Formulations for Improved Oral Delivery of Poorly Soluble Drugs; NSTI-Nanotech, 2006, vol 1, issue 1, pp. 475-478.
27. Prajapati T. Shailesh, Pathak Sarjak P, Thakkar Jalaram H, and Patel Chhaganbhai N.; Nanoemulsion based intranasal delivery of risperidone for nose to brain targeting; Bulletin of pharmaceutical research, 2015, vol. 5, issue 1, pp. 6-13.
28. Qidra El K. Raid; A Novel Ophthalmic Pharmaceutical Nano emulsion: Methods of Preparations, Characterizations, and Applications; American journal of pharmatech research, 2015,vol 5, issue 6, pp. 518-537.
29. Kashyap Nagariya, Sharma Kr. Peeyush; Nanoemulsion: Safe ,stable, and effective formulation system for ophthalmology; American journal of pharmatech research, 2013, vol. 3, issue 3, pp. 252-267.
30. Sarker Amit; Nanoemulsion: An excellent mode for delivery of poorly soluble drug through different routes; Journal of Chemical and Pharmaceutical Research, 2015,vol 7, issue 12, pp. 966-976.
31. Sampathi Sunita, Wankar Jitendra; Design, Development and Evaluation of Nanoemulsion and Nanogel of Itraconazole for Transdermal Delivery; Journal of Scientific Research in Pharmacy, 2014,vol 3, issue 1, pp. 6-11.
32. Shakeel Faiyaz; Design, development and evaluation of novel nanoemulsion formulations for transdermal potential of celecoxib; Acta pharm., 2007, vol. 57, pp. 315- 332.
33. Jaiswal Manjit, Sharma P.K.; Nanoemulsion: an advanced mode of drug delivery system. Biotech, 2015, vol 5,pp. 123-127.
34. Sinde P.B.; Component screening of Miconazole nitrate nanoemulsion; Asian journal of biomedical and pharmaceutical sciences, 2013, vol. 3, issue 19, pp. 33-40.
35. Basha Mona; Nanoemulsion as parentral drug delivery system for new anticancer benzimidazole derivative: Formulation and in-vitro evaluation; Egyptian pharmaceutical journal, 2016, vol. 14, pp. 166- 173.
36. Gannu Praveen Kumar, Ajmeera Divya; Nanoemulsion Based Targeting in Cancer Therapeutics; Medicinal chemistry , 2015, vol 5, issue 5,pp. 272-284.
37. Chouksey RK, Pandey H.K., Jain A.K.; Nanoemulsion: A review; Inventil spreading knowledge, 2011, vol 2, issue 1, pp. 982-988.

38. Elmarzugi A. Nagib; Nanoemulsion and Nanoemulgel as a Topical Formulation; IOSR Journal Of Pharmacy,2015, Vol 5,issue 10, pp. 43-47.
39. Gupta Ankur; Nanoemulsions: formation, properties and applications; Royal society of chemistry, 2016, vol 12, issue 11, pp. 1-16.
40. Tamaddon Mohammad Ali; Pharmaceutical Nanoemulsions and Their Potential Topical and Transdermal Applications; Iranian Journal of Pharmaceutical Sciences, 2011,vol 7, issue 3, pp. 139-150.
41. Sukanya G., Mantry Shubhrajit, Anjum Shireen; Review on nanoemulsion; International journal of innovative pharmaceutical sciences and research, 2013 vol. 1, issue 2, pp. 192-205.
42. Mishra Kumar Raj, Soni G.C., Mishra R.P.; Nanoemulsion: A Novel Drug Delivery Tool; International Journal of Pharma Research & Review, 2014,vol 3, issue 7, pp. 32-43.
43. Kumar Harsh; Nanoemulsion: A pharmaceutical review. International journal of pharma professional re22search, 2014,vol 5,issue 2, pp. 1031-1038.
44. Dhas Anuja; Review on nanoemulsion: A novel drug delivery system; European journal of biomedical and pharmaceutical science , 2016, vol 3, issue 4, pp. 156-166.
45. Chime S. A.; Nanoemulsions- Advances in formulation, characterization and applications in drug delivery; Intech, 2014.
46. Shah P.; Nanoemulsion : A pharmaceutical review; Sys Rev Pharm , 2010, vol 1,issue 1, pp.24-32.