POLYMERIC NANOPARTICLES BASED TOPICAL DELIVERY SYSTEMS IN PSORIASIS

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Abstract:

Psoriasis is a common inflammatory skin disease with an incompletely understood etiology. The disease is characterized by red, scaly and well-demarcated skin lesions. It is an immune – mediated chronic inflammatory skin disease affecting approximately 2-3% of worldwide population. Psoriasis has a negative impact on the patient's health and quality of life and affects the quality of family members. Skin and joints affecting around 0.5-1% of children and 2-3% of adults. It can occur at any age, although the majority of cases develop before the age of 40 year and it is common in Children. Psoriasis is a chronic inflammatory disease, predominantly affecting the skin included in the group of immune mediated inflammatory disease and several systemic condition like metabolic syndrome, cardiovascular disease, diabetes, Arthritis, obesity, hypertension, Cancer are prevalent in psoriasis patients. This review offers inside into management of psoriasis and pharmaceutical approach for treatment for this disease. The review deals in details about topical drug delivery, phototherapy and biological against psoriasis. Review provides a detailed summary of the pathophysiology, epidemiology, of psoriasis. This review also summarizes different technology of nanotechnology methods of preparations.[26]

Keywords: *Psoriasis, skin disorder, inflammation, therapies for disease, Nanotechnology therapies.*

Introduction

Psoriasis is a common inflammatory skin disease with an incompletely understood etiology. The disease is characterized by red, scaly and well demarcated skin lesions. [1] It is an immune mediated chronic inflammatory disease affecting approximately 2–3% of Caucasian population. It can occur at any age, although the majority of cases develop before the age of 40 years and it is uncommon in children. [2] Psoriasis is a chronic inflammatory skin disorder, immunologically mediated (Th-1, Th-17, and Th-22 activation and expansion, controlled by dendritic antigen-presenting cells).In the last years, an important progress has been made towards the identification of the inflammatory pathways involved in psoriasis pathogenesis. A series of inflammatory molecules are produced in psoriasis skin lesions (TNF, Il-1, Il-6, Il-8, IL-17, IL-22, Il-23, vascular endothelial growth factor (VEGF), interferon-γ, etc.) [3] Growing evidence suggests that cardiovascular disease, obesity, diabetes, hypertension, dyslipidemia, metabolic syndrome, nonalcoholic fatty liver disease (NAFLD), cancer, anxiety and depression, and inflammatory bowel disease are found at a higher prevalence in psoriasis patients compared to the general population. [4] Skin and joints affecting around 0.5-1% of children and 2-3% of adults. Typically, the patients develop Erythematous scaly papules and plaques. Up to 20 or 30% of patients with psoriasis develop psoriatic joint involvement, which may result in severe joint destruction and (in rare cases) mutilating arthritis. Both psoriasis of the skin and psoriatic arthritis are frequently accompanied by impairment of quality of life. [5]The environmental factors that appear to influence the course of and the susceptibility psoriasis include chronic infections, stress, low humidity, dru gs (beta blockers, lithium, antimalarial agents, and interferon), smoking, and obesity. [6] Psor iasis is a multifactorial inherited papulosquamous disorder common in pediatrics. It has been estimated that psoriasis affects 1% to 3% of the general population and although its true prevalence in pediatric patients remains to be established, it represents about 4% of all dermatoses in patients less than 16 years of age. Recent data has also shown that prevalence rates increase linearly from 0.2% at the age of 1 year to 1.2% at the age of 18 years. This same study also reported a total rate of psoriasis of 0.71% in patients younger than 18 years, making it a frequent consult in pediatrics, particularly in older pediatric patients. [4] Psoriasis has also been shown to adversely affect quality of life for children. [7]

The different types of psoriasis based on symptoms are given under:

- Plaque Psoriasis
- Guttate Psoriasis
- Inverse Psoriasis
- Erythrodermic Psoriasis
- Pustular Psoriasis
- Nail Psoriasis
- Scalp Psoriasis
- Psoriatic Arthritis

1. **Plaque psoriasis:** Plaque psoriasis is the most common form of psoriasis, affecting 80 percent of people with psoriasis. It often appears on the elbows, knees, lower back, and scalp. It is characterized by thick red patches of skin, often with a silver or white layer of scale.
2. **Guttate psoriasis:** Guttate psoriasis appears in small red spots on the skin. It is the second most common form of psoriasis. The spots often appear on the torso and limbs, but they can also occur on the face and scalp. They are usually not as thick as plaque psoriasis, but they may develop into plaque psoriasis over time.
3. **Inverse psoriasis:** Flexural or inverse psoriasis often appears in skinfolds (under the breasts, in the armpits, or in the groin area). It is very red and often shiny and smooth. Most people with inverse psoriasis also have a different form of psoriasis in other places on the body. The sweat and moisture from skinfolds keeps this form of psoriasis from shedding skin scales, and the skin-on-skin contact can make inverse psoriasis very irritating.
4. **Erythrodermic psoriasis:** Erythrodermic psoriasis is the rarest form of psoriasis, and it is very serious. This form of psoriasis looks like severe burns to the skin. It may cover large portions of the body, and exfoliation often occurs in larger pieces than the small scales typical to most psoriasis. It is very painful and may require hospitalization.
5. **Pustular psoriasis:** Pustular psoriasis is characterized by white pustules surrounded by red skin. The pus inside the blisters is noninfectious. Scaling also occurs. There are three kinds of pustular psoriasis: von Zumbusch, palmoplantarpustulosis (PPP), and a cropustulosis. Each of the three forms of this type of psoriasis have different symptoms and severity. Pustular psoriasis may affect isolated areas of the body, like the hands and feet, or cover most of the skin's surface.
6. **Nail Psoriasis:** Although not an official category of psoriasis, nail psoriasis is a manifestation of psoriasis that affects up to half of all individuals with psoriasis elsewhere on the body. The condition can often be confused with fungal infections and other infections of the nail. Nail psoriasis can cause nail pitting, grooves, discoloration, loosening or crumbling of the nail, thickened skin under the nail, and colored patches or spots under the nail.
7. **Scalp Psoriasis:** Several types of psoriasis may appear on the scalp. Some may cause severe dandruff, while others can be painful, itchy, and very noticeable at the hairline. It can extend to the neck, face, and ears, and it may be in one large patch or many smaller patches. In some cases, scalp psoriasis can make even regular hair hygiene difficult. Excessive scratching can cause hair loss and scalp infections, and the condition can be a source of social stress.
8. **Psoriatic Arthritis:** Psoriatic arthritis is a painful and physically limiting condition affecting up to 30 percent of those with psoriasis. It can affect many joints and often becomes quite severe in the hands. While there is no cure for psoriatic arthritis, some people achieve remission with arthritis treatments and exercises. [8]

Psoriasis:

Genetics of Psoriasis: The immune system plays a key role in psoriasis. Macrophage activation triggers an immune response that releases TNFα, IL1β, IL12, and IL23. Psoriasis has been associated with genes involved in the immune response, namely, *TNFα*, *IL12B*, and *IL23R*. However, there has also been associated with genes not involved in immune pathways, such as the early differentiation keratinization markers involucrin (*IVL*) and small

proline-rich protein (*SPRR*). These genes are involved in atypical epidermal cellular organization and differentiation and are upregulated in psoriasis Single-nucleotide polymorphisms (SNPs) in genes associated with psoriasis. T helper 17 (Th17) lymphocytes release IL22 and IL17,which are highly expressed in psoriatic skin. These lymphocytes also produce IL2, IFNγ, and TNFα . The pro inflammatory cytokine TNFα plays a key role in the pathogenesis of psoriasis .The inflammatory response in psoriasis is characterized by production of TNFα .Polymorphisms in the *TNFα* gene may alter the release of this cytokine in healthy subjects.

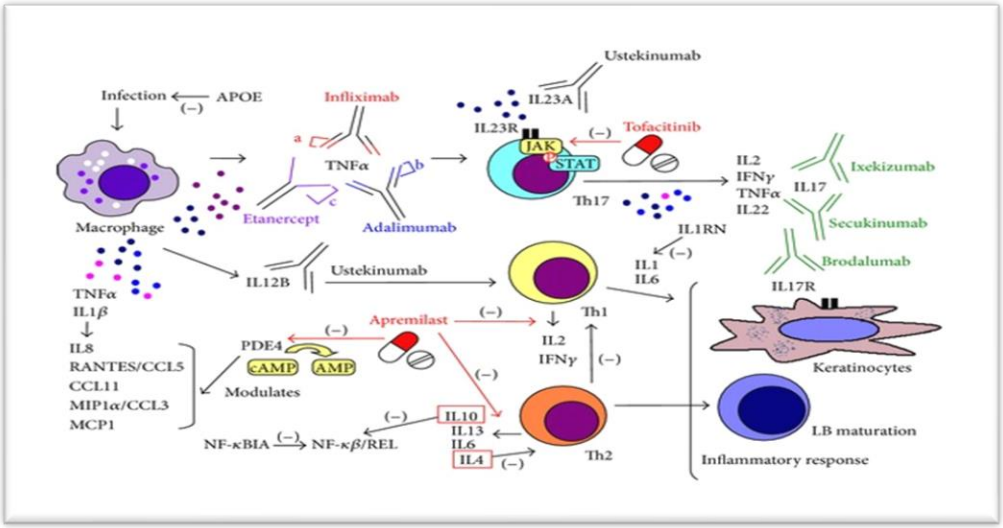

Figure 1: Genetics of psoriasis. [6]

Pathology and pathogenesis:

Psoriasis is a chronic, autoimmune disease affecting as many as 7.5 million Americans and 2% to 3% of the world population (data from National Psoriasis Foundation website). The most prevalent form of psoriasis, plaque psoriasis, is recognized by psoriatic plaques of red lesions covered by silvery white flakes on top of the skin. The pathogenesis of psoriasis is associated with both genetics and the immune system. As the current understanding of psoriasis, a stimulation of dermal dendritic cells activates the immune system including macrophages and T-cells and promotes the interaction between epidermal keratinocytes and the immune system. These events result in the up-regulated production of cytokines, which in turn causes the over-proliferation of keratinocytes starting from the basal layer of the epidermis and the overall skin inflammation associated with psoriasis lesion formation.[2]

Common skin changes in psoriasis:

Skin lesions covered with scales having thickened inflammation. Dry skin due to deficient natural moisturizing factor Imbalanced skin lipids Skin having tethered hair Skin sensitivity Corneocytes have excessive growth and aberrant differentiation Topical delivery into the psoriatic skin have lately been proposed to be addressed by the colloidal carrier systems, such as liposomes, niosomes and mixed miceller system, silica aerogeland ethosomes, lipid micro emulsion. The application of lipids in particular in these formulations resolves the problem of lipid imbalance and lack of moisture content. Thus, these lipoidal and allied carriers can result in an effective delivery of drugs across psoriatic skin.[9]

1. Central role of TNF-α in psoriatic inflammation:

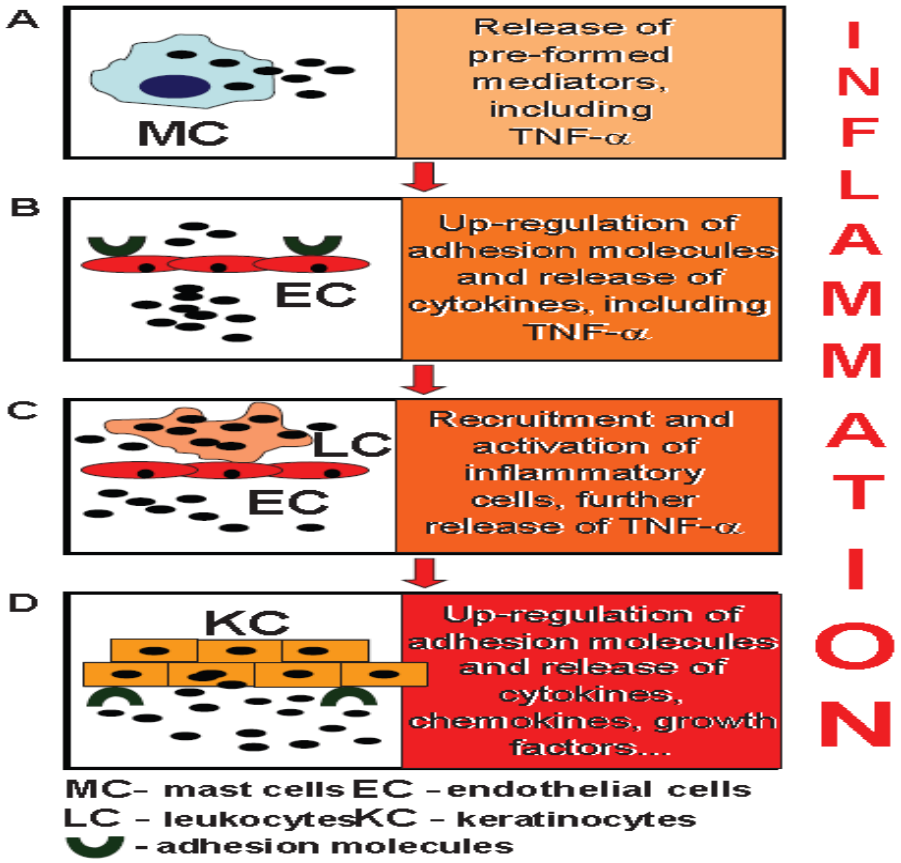

Figure 2: TNF-α-driven inflammatory cascade in the skin. Among the pre-formed mediators released by mast cells (**A**), TNF-α boosts the pro-inflammatory activation of resident cell populations which include endothelial cells (**B**). In their turn, endothelial cells respond to TNF-α with up-regulated expression of surface adhesion molecules, which facilitate the adhesion and migration of leukocytes to peripheral tissues, and a new wave of leukocyte-derived cytokine release (**C**). Eventually, skin keratinocytes amplify the inflammatory response at the local level, with massive release of cytokines, chemokines, and growth factors (**D**).

Abbreviations: TNF-α, tumor necrosis factor-α.

2. Psoriasis as a T cell-mediated skin disorder:

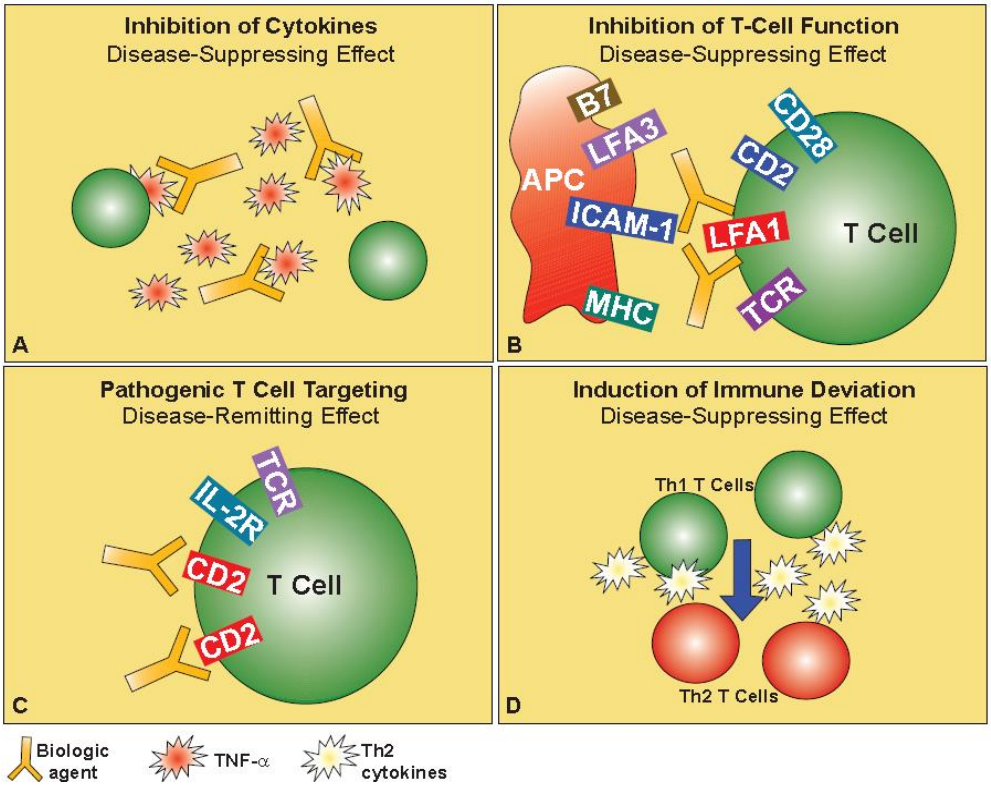

Figure 3: Strategies for targeted biological therapy of psoriasis. These include existing and potential biological drugs for the therapy of psoriasis, such as anti-TNF-α (**A**) oranti-LFA-1 (**B**) antibodies, inhibitors of CD2 expression on the surface of activated pathogenic T cells (**C**), or cytokines to balance the Th1-skewed immune response (**D**), theselast presently under investigation.

Abbreviations: APC, antigen-presenting cell; LFA-1, lymphocyte function-associated antigen-1; TNF-α, tumor necrosis factor-α.**[10]**

Different diseases caused by psoriasis:

Metabolic syndrome and psoriasis:

A recent meta analysis found that psoriasis patients have higher prevalence of MetS compared with the general population, and patients with more severe psoriasis have greater odds of MetS than those with milder psoriasis. In a large population-based study from UK, Langan et al. found that psoriasis is associated with MetS in a ‘‘dose–response’’ manner, with a 22% increase in the odds of developing the MetS in those with mild psoriasis, 56% increase in those with moderate disease, and a 98% increase in those with severe psoriasis. Next, the scientific evidence so far, concerning interrelationships between inflammation/psoriasis and each of the components of MetS, will be briefly summarized. [3]

There is different Diseases are caused by psoriasis are:

1. **Cardiovascular disease**

Patients with severe psoriasis were found to have a 5-year shorter life expectancy, with cardiovascular disease contributing significantly to this discrepancy. When cardiovascular risk factors were adjusted for, psoriasis patients still had an increased risk of stroke, atherosclerosis, myocardial infarction (MI), coronary artery disease (CAD), and endothelial dysfunction. Psoriasis, along with other chronic inflammatory systemic diseases, such as rheumatoid arthritis and systemic lupus erythematous, may be linked to increased cardiovascular disease risk because of common pathogenic mechanisms. Inflammatory cells and proinflammatory cytokines contribute both to the development of psoriatic lesions and to

the breakdown of atherosclerotic plaques. Psoriasis and atherosclerosis share a common pattern of Th1 and Th17 cytokine up regulation, T-cell activation, and local and systemic expression of adhesion molecules and endothelins.3 Activated T-cells near areas of inflammation produce type 1 cytokines such as interferon (IFN)-alpha, interleukin (IL)-2, and tumor necrosis factor (TNF)-alpha. IFN-alpha inhibits apoptosis, thus contributing to the hyper proliferation of keratinocytes. IL-2 stimulates T-cell proliferation. TNF-alpha is an inflammatory cytokine that is involved in the pathogenesis of both psoriasis and atherosclerosis. In psoriasis, TNF-alpha activates and increases keratinocyte proliferation. TNF-alpha has also been found to induce neutrophil chemo taxis, macrophage cytokine and chemokine production, and superoxide production, which can result in endothelial inflammation and dysfunction.

2. **Obesity**

   Obesity is considered a chronic, low-grade inflammatory condition. Inflammatory-type macrophages in adipose tissue stimulate the secretion of inflammatory mediators, which establish and maintain an inflammatory state. Adipose tissue then secretes adipocytokines, such as TNF-alpha, IL-6, and leptin, which may also play a role in the pathogenesis of psoriasis. Leptin provides information about the body's nutritional and fat mass to the hypothalamus and regulates appetite and body weight.

3. **Diabetes mellitus**

Type 2 diabetes mellitus (DM) is a metabolic disorder characterized by increased insulin resistance and hyperglycemia. Th1 cytokines that are overproduced in psoriasis are thought to promote insulin resistance as well. Obesity is a major risk factor for type 2 D.M, and the chronic secretion of inflammatory adipocytokines is also thought to contribute to psoriasis as well.

4. **Hypertension**

Although psoriasis and hypertension share common risk factors, such as smoking and obesity, psoriasis has been found to be independently associated with hypertension. The exact mechanism underlying the relationship between psoriasis and hypertension is unknown, but there are a number of hypotheses about this association. Alterations to the renin–angiotensin system in psoriasis may contribute to poor blood pressure control. Psoriasis patients have elevated plasma renin activity and elevated angiotensin-converting enzyme (ACE) activity. High ACE levels may play a role in altering cytokine regulation in vasculature. Certain ACE gene polymorphisms have also been associated with increased susceptibility to psoriasis, but these results are controversial.Endothelin-1, which is a potent vasoconstrictor, was also found to be elevated in the serum and lesional skin of psoriasis patients. Increased oxidative stress in psoriasis patients is also hypothesized to impair the vasodilatory mechanism of the endothelium.

5. **Cancer**

A number of studies have investigated the link between psoriasis and cancer; the data have been inconsistent, however. The chronic, inflammatory state induced by psoriasis is thought to initiate certain neoplastic diseases. As psoriasis is an immune-mediated disease, its pathophysiology is associated with an increased risk of lymphoma. This association is seen in other Th1-mediated diseases as well, such as rheumatoid arthritis. Patients with more severe

psoriasis may also be receiving drugs such as cyclosporine, methotrexate, or PUVA therapy, which have all been associated with malignancies. A higher prevalence of alcohol or cigarette abuse, risk factors for cancer, is also seen in psoriasis patients.[4]

Treatment for psoriasis:

The current therapies for psoriasis include topical agents, photo therapies, systemic therapy (immunosuppressive drugs) and biotherapies (biologics).

Table: 1 Treatment for psoriasis [9]

Antipsoriatics		
Topical	Tars	Tar
	Antracens	Dithranol
	Psoralens	Trioxysalen – Methoxsalen
	Other	Fumaric acid – vitamin D (Calcipotriol, Tacalcitol, Calcitriol) – Tazarotene
Phototherapy		Artificial or natural light sources
Systemic	Psoralen	Methoxsalen – Bergapten-Trioxysalen
	Retinoids	Etretinate – Acitretin

Table: 2 Emerging Biologics

Agent	**Description**	**Mechanism of action**
Secukinumab	Fully human monoclonal antibody directed against IL-17A	Blockade of IL-17A action
Brodalumab	Monoclonal antibody directed against IL-17 receptor	Blockade of IL-17A action
Ixekizumab	Monoclonal antibody directed against IL-17	Blockade of IL-17A action
Guselkumab (CNTO1959)	Fully human HuCAL-based antibody directed against the p19 subunit of IL-23	Blockade of IL-23 action
MK-3222/SCH-900222	Humanized monoclonal	Blockade of IL-23 action

	antibody directed against the p19 subunit of IL-23	
Tregalizumab (BT-061)	Monoclonal antibody directed against CD4 cells	Activation of regulatory T cells

Table no: 3 Drugs for treatment of psoriasis in market:[16]

Sr. no.	Brand name	Drug name	Class
1	Anucort-HC	Hydrocortisone	Topical steroids
2	Elocon	Mometasone	Topical steroids
3	Humira	Adalimumab	Antirheumatics, TNF alfa inhibitors
4	Lidex	Fluocinonide	Topical steroids
5	Neoral	Cyclosporine	Calcineurin inhibitors
6	Proctozone HC	Hydrocortisone	Topical steroids
7	Soriatane	Acitretin	Antipsoriatics
8	Tazorac	Tazarotene	Topical antipsoriatics
9	Topicort	Desoximetasone	Topical steroids
10	Trexall	Methotrexate	Antimetabolites, antip soriatics, antirheumati cs, other immunosuppressants

Topical Delivery Systems in Psoriasis

The standard of care for psoriasis can be categorized into systemic treatment, phototherapy and topical treatment. Illustrates these approaches and the associated side effects; the general concept applies for the treatment of other dermatological conditions as well. Standard of care for psoriasis categorized as systemic approach, phototherapy and topical approach.[2]Topical drug delivery has the capacity to achieve controlled and sustained drug delivery to provide predictable and extended duration of drug activity that many conventional modes of drug administration fail to achieve. The principal advantage of topical drug delivery lies in targeting the drug action directly to the site of disorder by allowing accumulation of high local drug concentration within the tissue and around its vicinity for enhanced drug action this is more effective when drugs with short biological half-life, narrow therapeutic window are applied with topical route. Such targeted drug action is unlikely to be attainable if drug is delivered via systemic pathway or from oral route. The major systemic and oral side effects as well as variable drug bioavailability associated with first-pass metabolism for drugs administered systemically can be avoided. Other advantages include ease of administration which will improve patient compliance. The success of topical drug delivery is dependent on the interplay among various factors; such as physiological factors of skin, physicochemical nature of the drug, formulation components and their interactions with each other, are among those to look for the success of this therapy.

These factors are:

Physicochemical nature of active substances

- Partition coefficient
- pH-condition
- Drug solubility
- Concentration
- Particle size
- Polymorphism
- Molecular weight
- Dermatological conditions
- Moisture content of skin
- Thickness of the skin treated
- Skin age
- Species variations
- Condition of the skin (intact/injured)
- Skin temperature
- Formulation content of topical product
- Vehicles
- Permeation enhancers
- Other additives

Thus, one can say that treatment of skin disorders through topical drug delivery has distinct advantages as compared to oral and parenteral administration but topical drug delivery is still a daunting task for formulators due to difficulties in controlling and determining the amount of drug reached at different skin layers. Physicochemical properties of drug and formulation components and their interaction are the factors which influence this distribution of drug among skin layers. A suitable colloidal delivery system for topical application may be prepared using physiological lipids which have good acceptance by the host body and cost effective too. A general criterion for the sele ction of optimal formulation parameters when developing a topical drug delivery system. [9]

Nanoparticles are defined as particles with all three dimensions confined within the range of 1 to 100 nm. [10-14] Nano dermatology is an emerging science that is gaining increasing recognition in the treatment of psoriasis. [15-25]

Polymeric nanoparticles-based topical delivery systems:

a) Natural polymeric nanoparticles

Natural polymeric nanoparticles are composed of polymers occurring in nature such as chitosan, alginate, gelatin and albumin. These natural polymers are usually obtained from extraction followed by various purification procedures. The tendency of these natural polymers to form hydrogels makes them ideal carriers for oligonucleotides, peptides, proteins and water-soluble drugs. For example, Pilocarpine hydrochloride-loaded gelatin nanoparticles were reported for topical ophthalmic use

b) Synthetic polymeric nanoparticles:

The most widely used polymeric nanoparticles are prepared from synthetic polymers. It is hard to obtain reproducible particles and controlled release pattern for the encapsulated drug(s). Compared to nanoparticles based on natural polymers, nanoparticles from synthetic polymers have been applied predominantly for hydrophobic/lipophilic drugs. Hydrophilic, biologically active molecules can be loaded into synthetic polymer-based nanoparticles by using the double emulsion method. Commonly used synthetic polymers for drug delivery applications include biodegradable aliphatic polyesters such as polylactides (PLA), poly(lactide-co-glycolide) copolymers (PLGA), and poly(ε-caprolactone) as well as non-degradable polymers such as poly(methyl methacrylate) and polyacrylates.

c) Nanoparticles made of biodegradable polymers:

PLGA copolymers are biocompatible and biodegradable; in the body, the final degradation compounds i.e. lactic acid and glycolic acid is eventually removed by citric acid cycle. These copolymers are the most commonly applied synthetic polymers for nanoparticle preparation, and PLGA nanoparticles have been widely employed for topical delivery. Poly(ε-caprolactone) is another synthetic polymer that is widely employed for the preparation of nanoparticle formulations due to its biocompatibility, biodegradability and mechanical properties. In addition, due to its semi-crystalline structure, its degradation is delayed compared with amorphous polyesters. Octyl methoxycinnamate loade d poly(ε caprolactone) nanoparticles for epidermal delivery of the loaded sunscreen agent; the results suggested better sun protection and partial protection against erythema.

d) Nanoparticles made of non-degradable polymers

Nanoparticles formulated with non-degradable polymers have also been studied for cutaneous delivery of active compounds. For example, Turos el al. developed a water-based emulsion system using non-degradable polyacrylates polymers. This new nano-formulation contains antibiotic-conjugated polyacrylates nanoparticles in which the drug monomer (an *N*-thiolated β-lactam antibiotic) is incorporated into the polymeric matrix by emulsion polymerization.

e) Tyrosine-derived nanospheres

A unique type of nanospheres, made of tyrosine-derived polymers from naturally occurring metabolites, has been developed at the New Jersey Center for Biomaterials, Rutgers University. The chemical structure of a typical ABA block copolymer used to prepare such the A blocks, poly(ethylene glycol) is hydrophilic, and the B block made from tyrosine-derived diol and suberic acid is hydrophobic. In aqueous medium, the block copolymers self-assemble to nanospheres with size approximately 70 nm. The nanospheres are trademarked as Tyrospheres™.[2]

Method of Preparation of Nanoparticles:

1. **Nanoparticles obtained from dispersion of preformed polymer:**

Dispersion of drug in preformed polymers is a common technique used to prepare biodegradable nanoparticles from poly (lactic acid) (PLA), poly (D, L- glycolide) (PLG),

poly (D, L-lactide –co –glycolide) (PLGA) and poly (Cyanoacrylate) (PCA). These can be accomplished by different methods described below.

a) Solvent evaporation:

In this method, polymer solutions are prepared in volatile organic solvents and emulsions are formulated by high speed homogenization or ultra-sonication and converted into a nanoparticles suspension on evaporation of solvent for the polymers, which is allowed to diffuse through the continuous phase of emulsion.

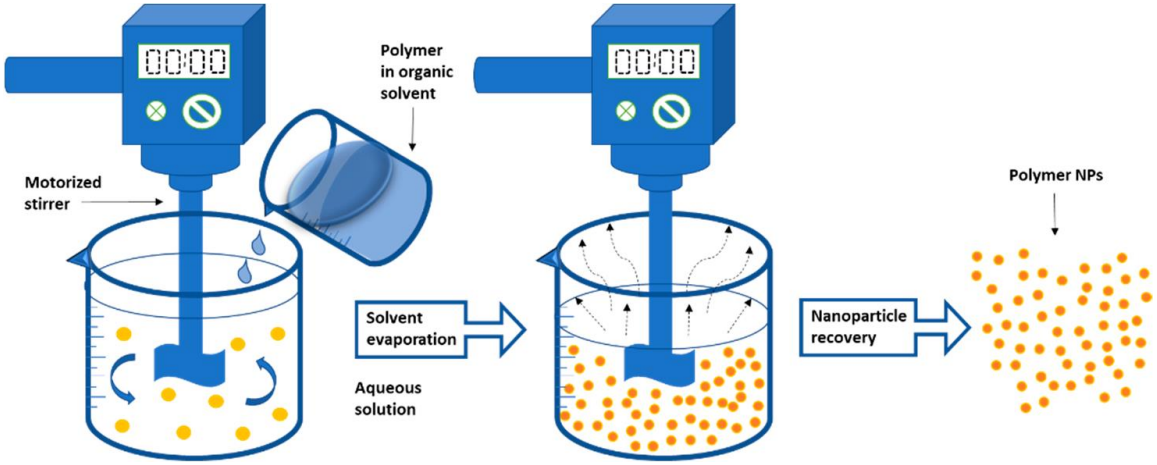

Figure 4: The emulsification-solvent evaporation technique is depicted schematically. [32]

b) Nanoprecipitation/ Solvent displacement technique:

In solvent displacement technique polymer is dissolved in an organic, water miscible solvent and then added into the aqueous phase in presence or absence of a surfactant. Addition of organic solvent from the oil phase to aqueous phase can diffuse immediately by which precipitation of polymer occurs and nanospheres are formed. Thus the solvent diffusion towards the aqueous phase generating nanoemulsion causes the polymers to precipitate uniformly within the nano-emulsion template.

c) Emulsification/ solvent diffusion:

In solvent diffusion method encapsulating polymer is dissolved in a partially water soluble solvent and saturated with water to ensure the initial thermodynamic equilibrium of both liquids. Subsequently the polymers water saturated solvent phase is emulsified in an aqueous solution containing stabilizer,which results to solvent diffusion to the external phase and the formation of nanospheres or nanocapsules. Finally he solvent is eliminated by evaporation or filtration according to its boiling point.

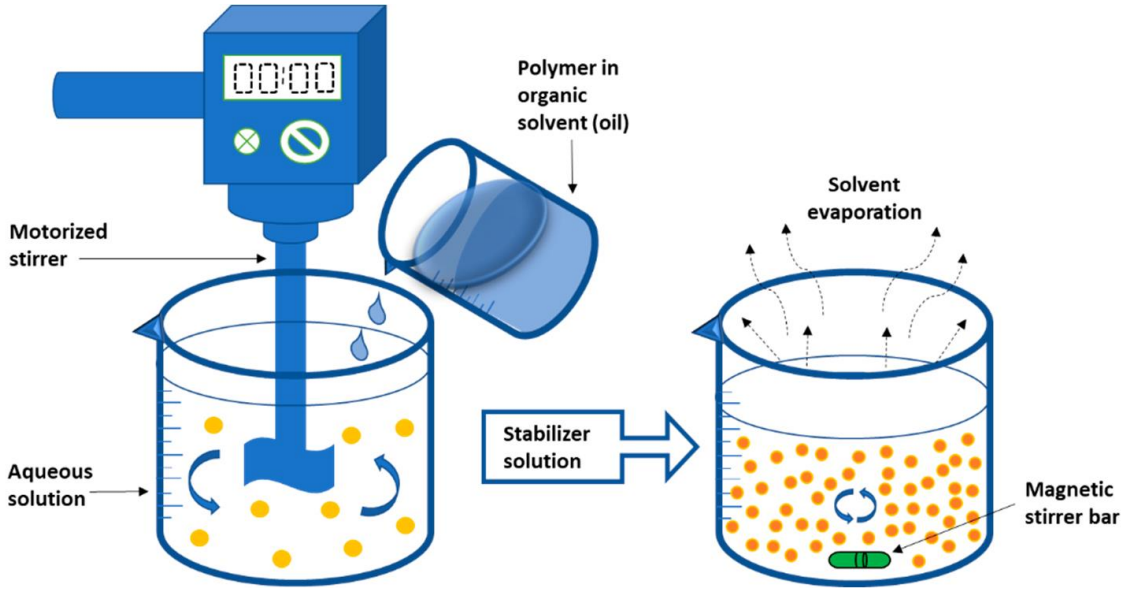

Figure 5: Diagrammatic representation of the emulsification solvent diffusion method.[32]

d) Salting out:

This technique is based on the separation of a water miscible solvent from aqueous solution via a salting out effect. Polymers and drug is initially dissolved in a solvent such as acetone, which is subsequently emulsified into an aqueous gel containing the salting out agent and a colloidal stabilizer thus inducing the formation of nanospheres.

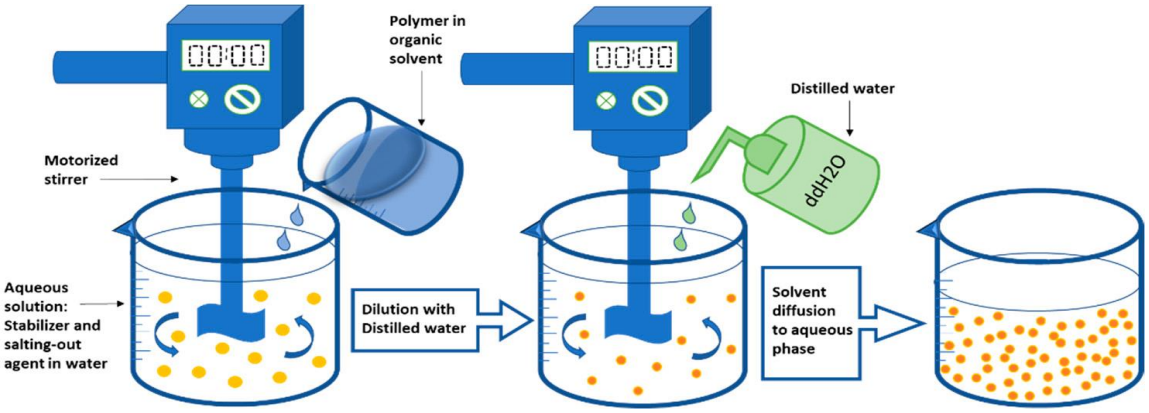

Figure 6: Preparation of nanoparticles (NPs) by salting out method.[32]

e) Dialysis:

In dialysis method the polymer and drug are dissolved in a suitable organic solvent. The resulting solution is introduced into a dialysis tube and dialyzed against deionized water. Water is exchanged at suitable intervals to remove the solvent.

2. Preparation of nanoparticles by polymerization of a monomer:

a) Emulsion polymerization:

This method is classified into two categories based on the use of an organic or aqueous continuous phase. The organic continuous phase methodology involves the dispersion of monomer into an emulsion or inverse micro emulsion, or into a material in which the

monomer is not soluble. In the aqueous continuous phase monomer is dissolved in a continuous phase that is usually an aqueous solution and surfactants or emulsifiers are not needed.

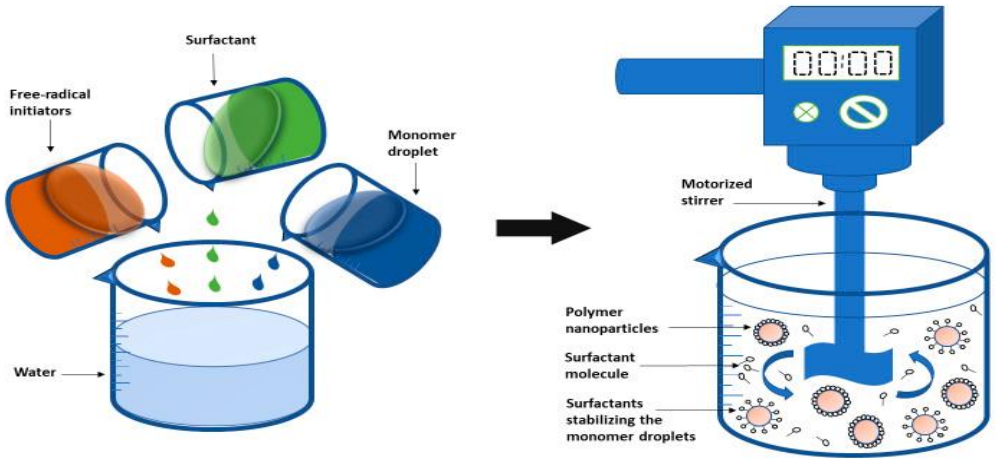

Figure 7: Preparation of nanoparticles by Emulsion polymerization. [32]

b) Interfacial polymerization:

It involves the polymerization of two reactive monomers or agents, which are dissolved respectively in two phases and the reaction takes place at the interface of the two liquids. Nanometer sized hollow polymer particles synthesized by employing interfacial cross linking reactions as poly-addition and poly-condensation or radical polymerization.

3. Ionic gelation or coacervation of hydrophilic polymers:

Polymeric nanoparticles are prepared by using biodegradable hydrophilic polymers such as chitosan, gelatin and sodium alginate involves a mixture of two aqueous phases, positively charged amino group of chitosan interacts with negatively charged tripolyphosphate to form coacervates with a size in the range of nanometer. Coacervates are formed as a result of electrostatic interaction between two aqueous phases, whereas, ionic gelation involves the material undergoing transition from liquid to gel due to ionic interaction conditions at room temperature. [26-32]

Conclusion:

Psoriasis is a topical disorder with unknown etiology and still after advancement in medical science complete cure of this disease is not yet established. Topical therapy whether it is conventional or novel is always choice of delivery system for pharmaceutical technocrats. Psoriatic skin pose a stiff challenge in designing a viable topical delivery system for delivery of antipsoriatic drugs and combining advantages of novel drug delivery system precisely colloidal drug delivery approaches provides a better drug delivery regime to the psoriasis treatment. Psoriasis vulgaris is the best-understood and most accessible human disease. That is mediated by T cells and DCs. The abi lity to measure cellular and molecular inflammatory pathways in diseased human tissue.

References:

1. *Baliwag J, Barnes DH, Johnston A, "Cytokines in psoriasis", "Department of Dermatology, University of Michigan MI 48109", (2015).*
2. *Gisondi P, Galvan A, Idolazzi L, and Girolomoni G. "Management of Moderate to Severe Psoriasis in Patients with Metabolic Comorbidities Front in Medicine", Vol. 2, No.1, (2015).*
3. *Voiculescu VM, Lupu M, Papagheorghe L, Giurcaneanu C, and Micu E. "Psoriasis and Metabolic Syndrome – scientific evidence and therapeutic implications", " Journal of Medicine and Life", Vol. 7, No. 4, (2014), PP. 468–47.*
4. *Catherine Ni and Chiu MW. "Psoriasis and comorbidities: links and risks", "Clinical Cosmetic Investigational Dermatology",Vol. 7, (2014), PP.119–132.*
5. *Belge K, Bruck J, and GhoreschiK. "Advances in treating psoriasis", Vol.6,(2014), PP.4.*
6. *Perez RP, Cabaleiro T, Dauden E, Ochoa D, Roman M, and Santos FA. "Genetics of Psoriasis and Pharmacogenetics of Biological Drugs Autoimmune Disease",(2013).*
7. *Corrales IL, Ramnarine S, and Lansang P. "Treatment of Childhood Psoriasis with Phototherapy and Photochemotherapy", Clinical Medicines Insights: Pediatrics .Vol. 7,(2013), PP. 25–33.*
8. *http://www.healthline.com*
9. *Chaturvedi SP. "A Review on Disease Management and Drug Delivery Aspects in Psoriasis Current Trends in Technology and Science", Vol.3, No. 1, (2012), PP. 122 – 125.*
10. *Bhatia, S. "Nanoparticles Types, Classification, Characterization, Fabrication Methods and Drug Delivery Applications, In Natural Polymer Drug Delivery System",(2016), PP. 33–93.*
11. *. Albanese, A.; Tang, P.S.; Chan, W.C. "The Effect of Nanoparticle Size, Shape, and Surface Chemistry on Biological Systems", Annu. Rev. Biomed. Eng. Vol.14, (2012), PP. 1–16.*
12. *Docter, D.; Strieth, S.;Westmeier, D.; Hayden, O.; Gao, M.; Knauer, S.K.; "impact of the nanomaterial-protein corona on nanobiomedicine. Nanomedicine", Vol. 10, (2015), PP. 503–519.*
13. *Joye, I.J.; McClements, D.J. "Production of Nanoparticles by Anti-Solvent Precipitation for Use in Food Systems'," Trends Food Sci. Technol", Vol. 34, (2013), PP. 109–123.*
14. *Pastore S, Gubinelli E, Leoni L, Raskovic D and Korkina L. Biological "drugs targeting the immune response in the therapy of psoriasis", "IRCCS", Vol. 2, No. 4, (2008), PP. 687–697.*
15. *Ezhilarasi, P.N.; Karthik, P.; Chhanwal, N.; Anandharamakrishnan, C. "Nanoencapsulation Techniques for Food Bioactive Components: A Review","Food Bioprocess Technol", Vol.6, (2013) PP. 628–647.*
16. *Sripriyalakshmi, S.; Jose, P.; Ravindran, A.; Anjali, C.H. "Recent Trends in Drug Delivery System Using Protein Nanoparticles", Vol. 70, (2014), PP. 17–26.*
17. *Bonifácio, B.V.; Silva, P.B.; Ramos, M.A.; Negri, K.M.; Bauab, T.M.; Chorilli, M. "Nanotechnology-based drug delivery systems and herbal medicines: A review", "Int. J. Nanomed", Vol. 9, (2013) PP.1–15.*
18. *Weiss, J.; Takhistov, P.; McClements, D.J. "Functional Materials in Food Nanotechnology", Vol. 71, (2006), PP. 107–116.*
19. *Kuhlbusch, T.A.; Asbach, C.; Fissan, H.; Göhler, D.; Stintz, M. "Nanoparticle exposure at nanotechnology workplaces: A review", Vol. 8, (2011), PP. 22.*

20. *Sanguansri, P.; Augustin, M.A. "Nanoscale Materials Development–A Food Industry Perspective", " Trends Food Sci. Technol", Vol. 17, (2006), PP. 547–556.*
21. *Rai, M.; Ingle, "A. Role of nanotechnology in agriculture with special reference to management of insect pests", Vol. 94, (2012) , PP.287–293.*
22. *Justin, C.; Philip, S.A.; Samrot, A.V. "Synthesis and characterization of superparamagnetic iron-oxide nanoparticles (SPIONs) and utilization of SPIONs in X-ray imaging", Vol., 7, (2017), PP. 463–475.*
23. *Aggarwal, P.; Hall, J.B.; McLeland, C.B.; Dobrovolskaia, M.A.; McNeil, S.E. "Nanoparticle interaction with plasma proteins as it relates to particle biodistribution, biocompatibility and therapeutic efficacy", Vol. 61, (2009), PP. 428–437.*
24. *Kharazian, B.; Hadipour, N.; Ejtehadi, M. "Understanding the nanoparticle–protein corona complexes using computational and experimental methods","Int. J. Biochem. Cell Biol", Vol.75, (2016), PP. 162–174.*
25. *Schöttler, S.; Landfester, K.; Mailänder, V. "Controlling the Stealth Effect of Nanocarriers through Understanding the Protein Corona", Vol. 55, (2016), PP. 8806–8815.*
26. *Amol T.Rangari*and Padmini Ravikumar "Polymeric Nanoparticles Based Topical Drug Delivery: An Overview", Vol. 5, No. 47, (2015), PP. 05-12.*
27. *Reis C P, Neufeld R J , Antonio J, Ribeiro , Veiga F. Nanoencapsulation I. "Methods for preparation of drug-loaded polymeric nanoparticles Nanomedicine: Nanotechnology, Biology, and Medicine", Vol. 2, (2006), PP.8–21.*
28. *Vauthier C, Dubernet C, Fattal E, Pinto-Alphandary CouvreurP."Poly (alkylcyanoacrylates) as biodegradable materials for biomedical applications", Vol. 55, (2003), PP. 519- 48.*
29. *Torini L, Argillier JF, Zydowicz N. "Interfacial polycondensation encapsulation in miniemulsion Macromolecules", Vol. 38, (2005), PP. 3225–36.*
30. *Scott C, Wu D, "Liquid-core capsules via interfacial polymerization: a free-radical analogy of the nylon rope trick", Vol.12, (2005), PP.4160–1.*
31. *Sarkar D, Khoury J, Lopina ST, Hu J.An, "Effective method for preparing polymer nanocapsules with hydrophobic acrylic shell and hydrophilic interior by inverse emulsion radical polymerization Macromolecules", Vol. 38, (2005), PP.8603–5.*
32. *Thiruchelvi Pulingam, Parisa Foroozandeh, Jo-Ann Chuah and Kumar Sudesh, "Exploring Various Techniques for the Chemical and Biological Synthesis of Polymeric Nanoparticles", Vol. 12, (2022), PP.576.*
33. *http://www.drugs.com.*