A Review on Hydrogel Developments

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***Abstract*- Hydrogels are three- dimentional hydrophilic polymeric networks with a high water holding capacity as well the ability to store biological fluids. The main purpose of this review article was to summarize the most recent trends of hydrogel technology, going through the most used polymeric materials and the hydrogels properties, such as cross-linking and the manufacture of composite hydrogels.The main objective of this article is to concern the classification of hydrogel on different basis, of hydrogel and its methods of preparation, physical & chemical characteristics. Hydrogels can retain a large quantity of water within their network without disturbing their original adhesions tructure. This imparts flexibility and swelling properties to the hydrogel structures. As a result, hydrogels are commonly used in clinical practice and medicine for a wide range of applications, including Tissue engineering and Regenerative medicine, Diagnostics, Cellular immobilization, separation of biomolecules or cells, and barrier materials to regulate biological.**

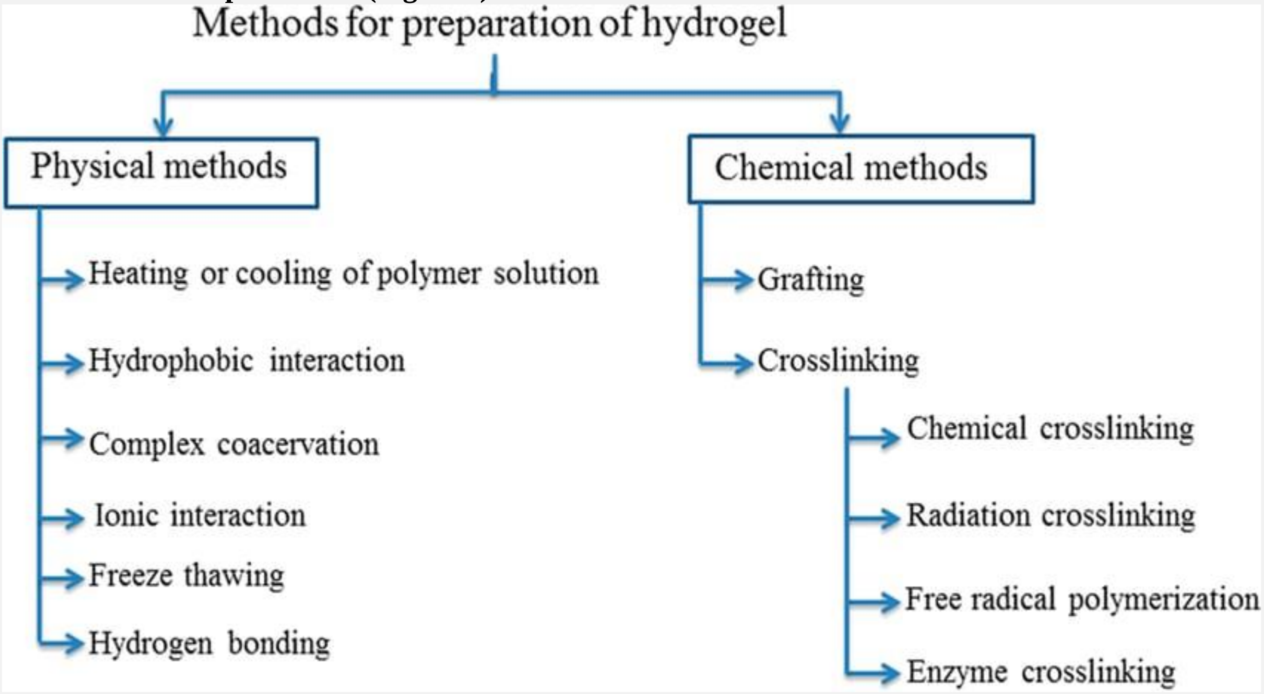
***Keywords:* Hydrogels, Polymers, Biomedical,Stuctures, Physical and Chemical Crosslinking, Methods of Preparation, Applications.**

INTRODUCTION:

Hydrogels can detain massive quantities of water molecules or biological fluids. Hydrogels are also referred to as polymeric mixtures that swell but don't dissolve in H2O.(1) They possess a degree of flexibility very similar to natural tissue due to their large water content. The ability of hydrogel to absorb water arises from hydrophilic functional group attached to polymeric backbone, while their resistant to dissolution arises from crosslinks between network chains.(2) The word hydrogel was initially introduced by Van Bemmelen in the year 1984, later described by Wichterle and Lim.(3) Biocompatibility is promoted by the high water content of hydrogels and the physiochemical similarity of hydrogels to the native extracellular matrix, both compositionally (particularly in the case of carbohydrate-based hydrogels) and mechanically. Biodegradability or dissolution may be designed into hydrogels via enzymatic, hydrolytic, or environmental (e.g. pH, temperature, or electric field) pathways; however, degradation is not always desirable depending on the time scale and location of the drug delivery device.(4) Hydrogels have interesting biomimetic properties, such as remarkable flexibility, softness, superior absorption capacity in their swollen state, nontoxicity, biocompatibility, biodegradability and tunable mechanical properties.(5) In addition to biomedical applications, hydrogels are also very appealing for many applications, such as self-assembly and catalysis, among others.(6)

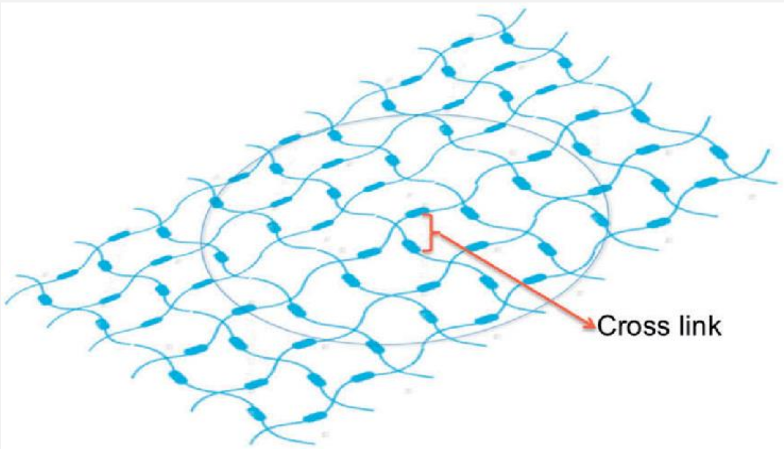
- **Advantages:-** 1) It may be low toxicity.
  2)It should be biodegradable, good tranport properties.
  3)Hydrogels is more elastic and stronger**.**
  4)It have capability to change temperature, pH and Concentration.
- **Disadvantages:-** 1)High cost.
  2)It can be hard to handle.
  3)Difficult to sterilize.
  4)It has low mechanical strength.

- **Methods of Preparation:- (Fig.no-1)**

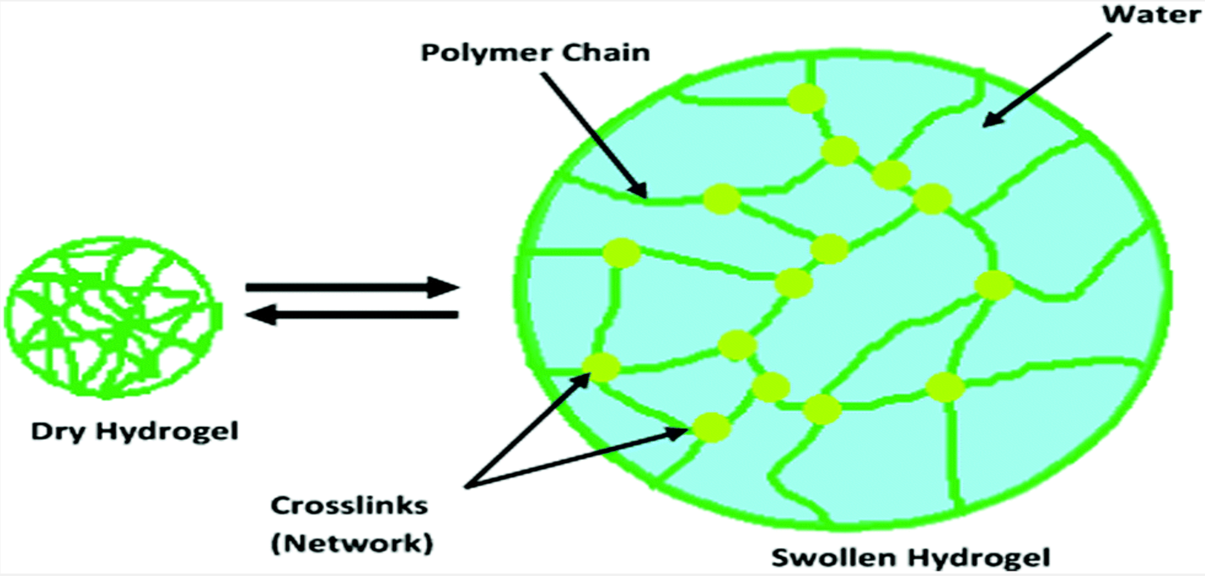


- **Structure of Hydrogel:-**

Some synthetic polymer hydrogels are included cross- linking hydrogel, water in hydrogel, poly (vinyl alcohol), poly (hydroxyethyl methaacrylate), polyvinyl pyrrolidone, polymidine, polyacrylate, polyurethane, polyethylene glycol and derivatives.[7]



(Fig.no-2)



(Fig. no-3)

CLASSIFICATION OF HYDROGEL:-

➢ **Based on Source**:- Hydrogels are categorized as natural, synthetic, hybrid, or semi-synthetic based on their origins.[8-9]

1) Natural hydrogels: Natural hydrogels are biodegradable, biocompatible and good cell adhesion properties.[10]Hydrogels prepared from a natural source can be a good candidate as they show appreciable biocompatibility. In addition, they also exhibit disadvantages like poor mechanical properties and lower stability.[11]

2) Synthetic hydrogels: Synthetic hydrogels are more important than natural hydrogels in usage, due to their easy fabrication and tailoring features. Therefore, synthetic hydrogels are prominent material for biomedical applications.[12] Its widely used material in biomedical application due to their non-toxicity there compatibility and low immunogenicity.

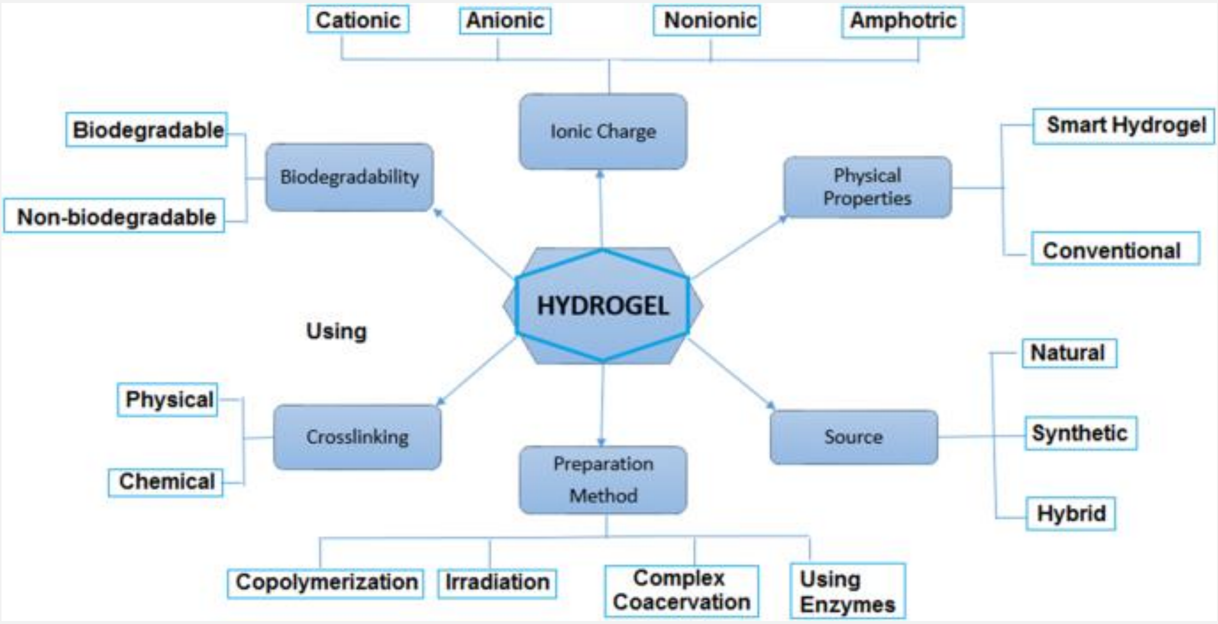
3. Hybrid hydrogels: They are the combination of natural and synthetic polymer hydrogels. There are numerous reports on hydrogels reported in biomaterial applications.[13-14] By combining the two polymers, a semi-interpenetrating hydrogel network of silk fibroin and poly acrylamide was created and used as a drug release matrix.[15]

➢ **Based on Polymeric Composition:-** [16-21] Hydrogels can be categorized as homo-polymers, co-polymers, semi-interpenetrating networks, and interpenetrating networks depending on their composition.

1) Homopolymeric hydrogels:- It is known as the polymeric network which acquire from a single species of the monomer. In addition, semiinterpenetrating network hydrogels are provided with chemical bonds via diffusion of one into another linear polymer cross-linked polymer chain network.

2) Co-polymeric hydrogels: Co-polymeric hydrogels are comprised of two or more different monomer species with at least one hydrophilic component. Copolymers are built up of two or more dissimilar monomer units.

3) Multipolymer Interpenetrating polymeric hydrogels (IPN) :- In this type of classification one polymer is noncross linked polymer network. Interpenetrating network (IPN) hydrogels were studied by several researchers. These IPN have network-like structures that are prepared of two cross-linked natural or synthetic polymer components that are separately cross-linked.



(Fig.No:-4)

➢ **Based on Hydrogel Confifuration:-**(22-23) The classification of hydrogels depends on their physical and chemical composition can be classified as follows:-

1. Amorphous (non-crystalline)
2. Semi crystalline: A complex mixture of amorphous and crystalline phases
3. Crystalline.

The degree of crystallinity is dependent on the cooling rate and structure of the polymer. It can range from an entirely amorphous polymer (nearly 0%) to a semi-crystalline polymer (95%).

➢ **Based On Hydrogel Crosslinking:-**(24-25) Hydrogels can be divided into two categories based on:-

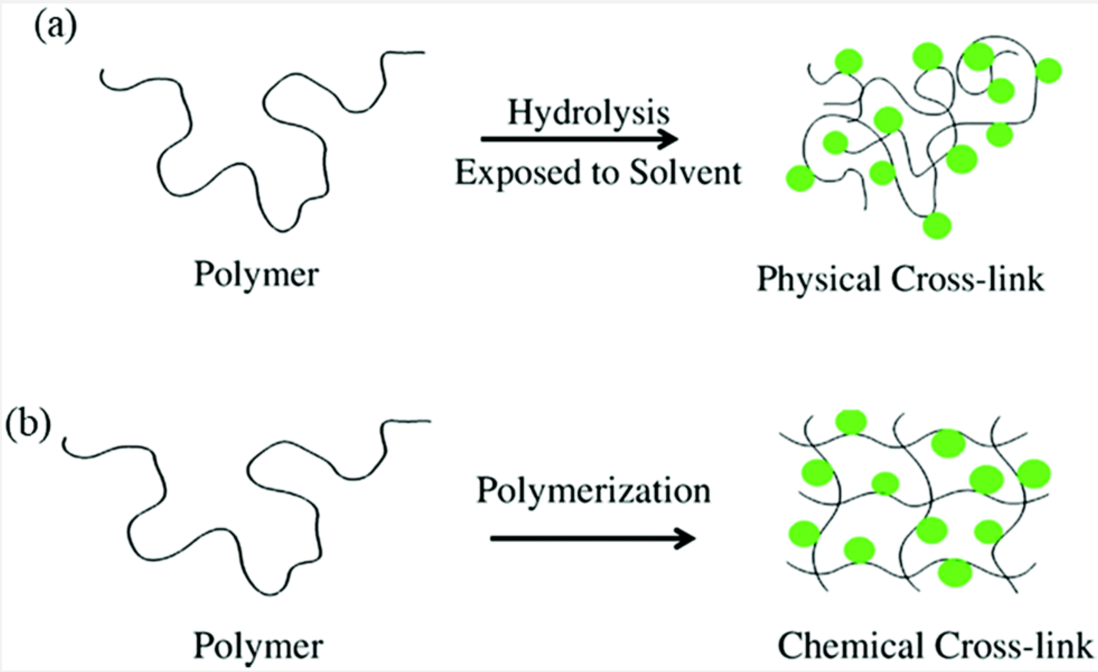
1.Physical Crosslinking:- Physical networks have transient junctions.

2.Chemical Crosslinking:- Chemically cross-linked networks have permanent junctions.

Molecular tangles or additional factors, such as hydrophobic interactions or ionic hydrogen bonding hold the networks together in this kind.

Permanent cross-linking gels are designed by a covalent cross-linking hydrogen bond and constant covalent bond.

Many collaborative reactions are involve for the cross linking process such as Michael's reaction, Michaelis-Arbuzov reaction, and nucleophilic addition reactions.



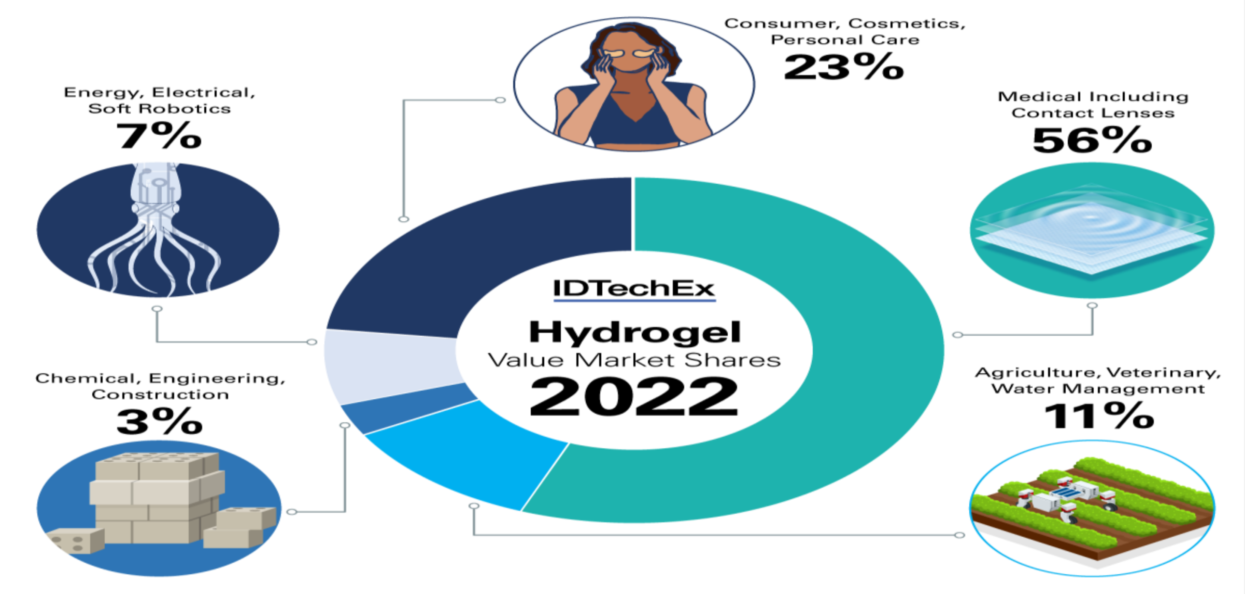
(Fig.No.5)

APPLICATIONS OF HYDROGELS:-

The research field of hydrogels is evolving and gaining recognition over the years, their structure (high content in water), degradation and release capacity make them suitable candidates as water reservoirs in agriculture or horticulture for those areas where there is a shortage of water for crop irrigation.[26]

From a future perspective, there is another issue that these technologies must overcome, as contemporary hydrogels are mainly designed for a single purpose, but in practical biomedical applications, more work needs to be done.[27]

(Fig.No.6)



CONCLUSION:

In the present review, the authors tried to elaborate briefly on hydrogels and biomedical uses. New strategies have been developed by means of synthesis and cross-linking procedures and the incorporation of different materials such as metallic and non-metallic NPs or secondary interpenetrated polymeric networks to implement novel functionalities and substantially improve physicochemical and biological properties. Hydrogels have played a significance role in biomedical field i.e. drug delivery, tissue engineering, wound dressing, environmental, bacterial culture. Hydrogel based delivery devices can be used for oral, ocular, epidermal, subcutaneous application due to their high water contents and soft consistency hydrogels resemble natural living tissue more than any other class of synthetic biomaterials. Instead of conventional creams, the hydrogels have been formulated for better patient compliance.

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