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Correspondence

Hydrogel Drug Delivery System (HDDS): Contribution by Pakistani Researchers

Abdul Mujeeb[1], Nazar Mohammad Ranjha[2]* Tariq Mahmood[1]

[1]School of Pharmacy, The University of Faisalabad, West Canal Road, Faisalabad, 37610, Pakistan

[2]Professor, Department of Pharmacy, Bahauddin Zakariya University, Multan, Pakistan

*E-mail of the corresponding author: nazar_ranjha@hotmail.com

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Dear Editor,

Hydrogels are hydrophilic polymeric networks that are able to swell and retain large amounts of water or biological fluids. Hydrogels work well in the body because they mimic the natural structure of the body's cellular makeup. As a result of this, the area of hydrogel research has expanded dramatically in the recent years, primarily because they perform well for biomedical applications (Kunzler et al., 2003). Recent advances in the use of hydrogels have led to the potential to design artificial organs, deliver drugs to specific sites in the body in a controlled fashion and fabricate the extended wear contact lenses (Lin and Metters, 2006); Hoare and Kohane, 2008). Hydrogels can absorb water nearly 10-20 times its molecular weight and hence become swollen. Their affinity to absorb water is attributed to the presence of hydrophilic groups such as –OH, –CONH–, –CONH2–, and –SO3H in polymers forming hydrogel structures (Peppas et al., 2000). Hydrogel technologies may be broadly applied to wound dressings (Azad et al., 2004), superabsorbent, barrier materials to regulate biological adhesions, biosensor devices, tissue engineering and regenerative medicines, diagnostics and separation of biomolecules or cells and pharmaceuticals (Kumar et al., 2008). Hydrogels may be classified as natural or synthetic depending on the nature of their origin. They can be classified as neutral or ionic according to the nature of the side groups. On the basis of the physical structure of the networks, they can be classified as amorphous, semicrystalline, hydrogen-bonded structures or hydro colloidal structures. Finally, they can be homopolymer or copolymer based on the method of preparation. A truly amazing class of hydrogels that has found potential use for a wide variety of applications is the class of "smart" or "intelligent" hydrogels. The uniqueness of this class is due to the unusual volume changes that these polymers exhibit under the application of very specific stimuli. Smart hydrogels exhibit significant volume changes in response to stimuli such as changes in pH, temperature, electric field, ionic strength and light etc. Research efforts on the design of smart hydrogels for drug delivery application have increased significantly over the past few years; the idea behind this approach is that smart hydrogels will both expand and contract, forming a hydrogel "switch" that releases drug or protein in a controlled fashion. The developments in this area of research have been extensively reviewed periodically by various scientists (Roy et al., 2010; Pathan et al., 2008). But Ranjha and his co-workers are thought to be the pioneer for their research on hydrogels drug delivery system (HDDS) in Pakistan. They prepared various types of hydrogels by using various types of monomers and polymers from natural and synthetic origin. Different methods were utilized to synthesize hydrogels like physical and chemical crosslinking by using various crosslinking agents and initiators (Ranjha, 1999). Majorly polymers used were of hydrophilic nature and of low molecular weight to produce a hydrogel that are biodegradable and biocompatible for targeted release. Then work was directed towards stimuli responsive hydrogels which shows maximum swelling at a particular pH to release drugs (Ranjha, 1999). After formulating these novel drug delivery vehicles, physical parameters including swelling studies, porosity and sol-gel analysis have been studied to measure the effect of monomeric/polymeric composition used to prepare these hydrogels. Hydrogels have been loaded with various therapeutically active agents to release drug at particular pH and release studies have been focused in vitro by the rate of dissolution, using buffer solutions of various pH

(Ranjha and Mudassir, 2008). Release rate of loaded drugs have been evaluated by pharmacokinetic studies by applying zero order, 1st order, Higuchi, Peppas and Korsmeyer models (Ranjha et al., 2008). Hydrogels have been characterized for surface morphology, crystallinity, change in structure and thermal decomposition by scanning electron microscopy (SEM), X-ray Diffraction (XRD), Fourier transform infrared (FTIR) and thermogravimetric analysis respectively (Mudassir and Ranjha, 2008; Ranjha et al., 2010). Now Ranjha et al., are emphasizing on nanoparticulate hydrogels for delivery of various macromolecules for the treatment of various diseases. But more recently, another hydrogel oriented research is also being carried out by Minhas et al., in Pakistan. They developed co-polymeric networks which are highly pH responsive and these hydrogels preparations have been proposed in treatment of colorectal cancer (Minhas et al., 2013). Recent advances in the development of novel hydrogels for drug delivery applications have focused on several aspects of their synthesis, characterization and behavior. Obviously drug release from hydrogel networks is controlled by a complex combination of different mechanisms, such as matrix swelling, drug dissolution/diffusion, hydrogel erosion and stimuli responsive. Successful design of drug delivery systems relies not only on proper network design but also on precise description of hydrogel behavior. Hydrogels are thought advanced release devices so more rigorous mathematical and statistical modeling approaches are needed to describe the complete mechanisms governing drug release from these systems.

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