and bioavailability of therapeutic drugs in pulmonary system, especially because of the effectiveness and precision associated with this approach [52]. But results obtained from these studies are hard to transfer this approach as an aerosol form in human. Whereas inhalative administration method uses the aerosol technique and facilitates the uniform distribution of drug with effective penetration [53].

Despite this the approach is expensive and ineffective in determining the exact dosage in pulmonary system. There are three main mechanisms such as diffusion, gravitational sedimentation, and inertial impact that are involved in drug deposition through aerosol administration method. In case, where size of drug is larger, then deposition of drug take place by gravitational sedimentation and inertial impaction [53]. Whereas when the drug is smaller in that diffusion mechanism comes into play and follows the rule of Brownian motion. Other than the morphology aspect of the pulmonary system, parameters like the size of drug droplets or particles and geometry are very important. Additionally the size of the drug droplet or particles in relation with diameter, surface charge and shape are also crucial, as they determine the influence of deposition of drug via pulmonary route [54]. On analyzing the mechanism of drug administration in the pulmonary system, although the conventional techniques are effective in relieving the patient suffering from respiratory disease but during the ADME process of drug, the concentration of the drug at target site is lower than the desired dosage. Hence, nanocarrier drug delivery system has gained the interest of pharmaceutical industry to invest in the development of these nanocarrier system [55].

4. NANOCARRIER DRUG DELIVERY SYSTEMS

4.1. Advantages of Nanocarrier Drug Delivery System

In recent years, the use of nanotechnology in the field of medicine has gained significant attention [56–59]. Particularly, the nanocarrier drug delivery system is the emerging field due to its associated advantages such as improved circulation time of drug, high concentration of drug at targeted site, reduced degradation and loss of drug, and most important is its easy administration procedure [60–62]. With the application of nanoparticle, it is easy to regulate the release of drug at the targeted site. Generally the nanocarriers are the colloidal particles within the size range of 10–200 nm [63, 64]. The selection of nanocarrier depends on the nature of drug which is to be entrapped inside these nanocarriers by different techniques that are retained on the basis of their interaction between nanocarrier and drug. As the interaction of drug is not compatible with all the types of nanocarriers [65]. To date, various different types of nanocarrier systems have been developed named carbon nanotubes, dendrimers, liposomes, mesoporous silica, micelles, polymeric nanoparticles, protein nanoassemblies, and many more. On the basis of the material and variation on the surface, these nanocarrier systems possess different drug release characteristics and properties [16]. These nanoparticles share a high resemblance with biological entities such as viruses and proteins, which allows them to interact with cell surface and with the cells. Due to which nanocarrier system has gained a lot of attention and various new nanocarriers are being developed with different properties, making it difficult to underline all new findings [66]. Still, some of the properties which are important for developing an effective drug delivery nanocarrier system is illustrated in Fig. 1 and comprehended below:

4.1.1. Easy surface amendment

Mostly surface amendment of nanocarrier system is done to improve the biodistribution and circulation time. For example, hydrophobicity often aids in binding of these nanocarriers with blood components. Whereas nonamended surface hydrophobic nanocarriers are easily removed by our own system [67]. Therefore to enhance the circulation time of these nanocarrier in blood, these nanocarriers are coated with hydrophilic polymers or surfactants like chitosan and polyethylene glycol (PEG). Interestingly, PEGylated nanocarrier have shown improved mucous penetration, whereas chitosan-amended nanocarriers have shown improved circulation time [68]. These benefits of nanocarrier system highlight their importance in treating CRDs, as it prolongs the availability of therapeutic agent at the target site. Other than modifying these nanocarrier system with chemical agents, they can also be amended by biological fluid which forms corona properties on the surface, which changes the properties of nanocarrier [69]. Additionally, the modification of these nanocarrier with phospholipids has drastically improved the cellular uptake and the toxicity of it [70].

4.1.2. Targeted delivery

Nanocarrier drug delivery system offers the additional benefit of specific cell or tissue targeting, which has greatly improved therapeutic effect of the drug and reduces the chances of drug toxicity [71]. This targeting is achieved by both the active and passive drug delivery method. Passive accumulation of these nanocarriers has