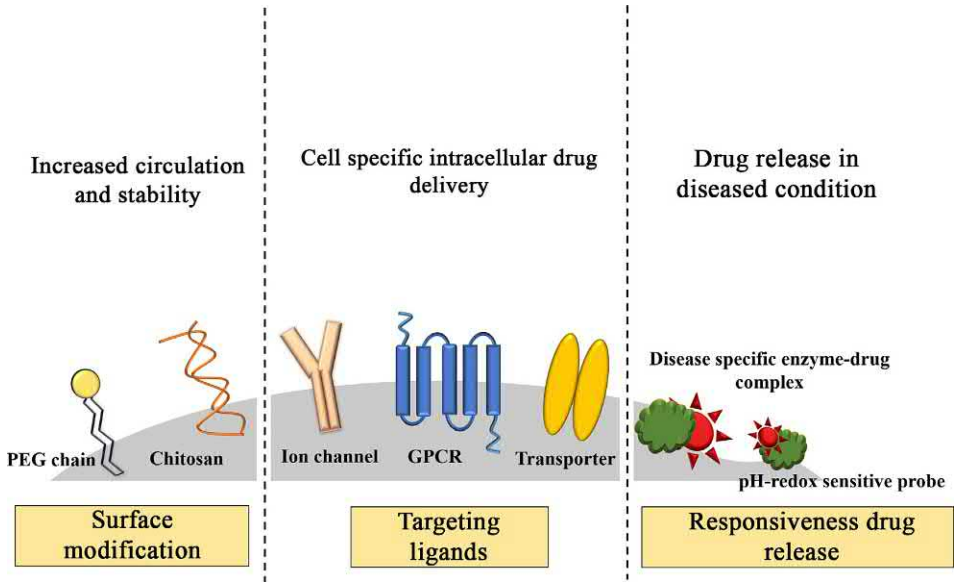

FIG. 1 Diagrammatic illustration of the properties important for developing nanocarrier system for drug delivery.

been found to improve permeability and retention time of the drug. Moreover, charge on the nanocarrier system also aid passive targeting [72]. For example, paclitaxel loaded in cationic liposomes were compatible to target the endothelial cells in tumors of cancer patient. Moreover, passive uptake of these nanocarriers by macrophages aid in targeted drug delivery, as in case of TB the microbe *M. tuberculosis* resides in the macrophages [73, 74]. On the other hand, active targeting involves the interaction between the targeted ligand with nanocarrier surface which has an affinity for specific molecule in the diseased cell. For example, liposomes loaded with doxorubicin have been developed which targets integrin molecule on colon cancer cells and inhibits their progression, which was an advantage of this modified liposome over the traditional liposomes. Hence, conjugation of the cell-specific entity on the nanoparticle aid in targeting the specific cell and increases the specificity of the therapeutic agent [75].

4.1.3. Regulated release of drug

For therapeutic success, regulated release of therapeutic agent from nanocarrier is important. Control release of drug from these nanocarriers could be sustained or stimuli response [76]. In case of liposomes and polymeric nanocarriers, there is a sustain release of the drug either by the process of diffusion or gradual degradation these nanocarriers over the period of time. Whereas stimuli-responsive release of the therapeutic agent is more targeted approach and can be achieved by altering the biological environment by changing the pH or disease-targeted enzyme [77]. For example, the nanocarrier synthesized with pH sensitive linkers attached on the surface, allows the easy removal of outer coat made up of polymer on their uptake [78]. In another example, PEG-peptide-lipid conjugate nanocarriers were used for the responsive release of the therapeutic agent, as the PEG molecules get removed from the nanocarrier surface by the action of matrix metalloproteinases, as they are overexpressed in the tumor cells [79, 80].

5. DRUG DELIVERY APPROACHES FOR PULMONARY RESPIRATORY DISEASE

There are numerous nanocarriers drug delivery system that have been developed for treating these CRDs as depicted in Fig. 2. Additionally, these nanocarrier drug delivery systems have been briefly discussed later in the following subsections:

5.1. Liposomes

Liposomes are spherical-shaped nanocarriers of lipid bilayers made up of cholesterol and nontoxic phospholipids. Generally, it comprises an aqueous core in center which is surrounded by lipid bilayer resembling the