7. CONCLUSION

Controlled-release formulations were able to achieve the two most sought after characteristics in any dosage form: temporal delivery and spatial location. They have helped the pharmaceutical industry in acquiring a more patient-oriented approach. In this review, we have discussed the basic terminology of modified-drug release, rationale for development of solid oral controlled-release dosage form, various polymers used, types of formulations, and characterization of oral controlled-release formulations. Controlled-release formulations have improved the patient compliance through desired therapeutic efficacy with minimum side effects and decreased the dosing frequency.

8. FUTURE PROSPECTS

Solid oral controlled-release formulations have opened a plethora of opportunities for the pharmaceutical industry such as "personalized medication" or "tailor-made medication" that is going to be a milestone in the coming years. On the manufacturing front, the use of automation will help us to manufacture oral controlled-release formulations with better safety, efficacy, and lower costs. The global market is predicted to grow from US$ 493.2 billion in 2017 to US$ 926.3 billion by the end of 2027, according to a report from The Express Wire [9].

Moreover, regulatory guidelines related to quality by design have further improved the specification and rationale behind the development of the product with quality commitment. Newer process and analytical tools will help industries to understand the effects of process and formulation variables on the performance of formulation. Integration of existing advanced controlled-release system can overcome the shortcomings of individual delivery system, such as controlled delivery with stimuli-responsive or targeted delivery [89]. Furthermore, the delivery of nanocarriers or large molecules through oral delivery is challenging. There is scope to use variety of newer polymers from synthetic origin or natural origin, which can provide improved stability, biocompatibility, and targeted delivery. In recent developments, 3D printing technology has opened the new dimensions for personalized solid oral therapy. This technology involves additive manufacturing of computer-designed models of delivery systems using selected polymers. A combination of 3D printing technology with stimuli responsive drug delivery systems has been attempted and is called as the 4D printing technology [90]. However, there is a need to explore the suitability of industrial feasibility and regulatory acceptability for such newer delivery systems. Therefore controlled-release formulation is a booming field in the pharmaceutical industry, and more development is expected in the coming years.

REFERENCES

[1] Y. Perrie, T. Rades, Controlling drug delivery, in: Pharmaceutics: Drug Delivery and Targeting, 2009, pp. 1–24.

[2] S.I. Jethara, Sustained release drug delivery systems : a patent overview. Aperito J. Drug Design. Pharmacol. 1 (2) (2015) 107–129, https://doi.org/10.14437/AJDDP-1-107.

[3] P. Viswanathan, Y. Muralidaran, G. Ragavan, Challenges in oral drug delivery: A nano-based strategy to overcome. in: Nanostructures for Oral Medicine, 2017, pp. 173–201, https://doi.org/10.1016/B978-0-323-47720-8.00008-0.

[4] R. Shaikh, D.P. O'Brien, D.M. Croker, G.M. Walker, The development of a pharmaceutical oral solid dosage forms. in: Computer Aided Chemical Engineering, vol. 41, 2018, pp. 27–65, https://doi.org/10.1016/B978-0-444-63963-9.00002-6.

[5] D. Psimadas, P. Georgoulias, V. Valotassiou, G. Loudos, Molecular nanomedicine towards cancer. J. Pharm. Sci. 101 (7) (2012) 2271–2280, https://doi.org/10.1002/jps.

[6] D. Barbieri, Meeting the challenges of paediatric dosing, ONdrugDelivery 2017 (2017) 38–39.

[7] H. Gupta, D. Bhandari, A. Sharma, Recent trends in oral drug delivery: a review. Recent Pat. Drug Deliv. Formul. 3 (2) (2009) 162–173, https://doi.org/10.2174/187221109788452267.

[8] H. Seager, Drug-delivery products and the Zydis fast-dissolving dosage form. J. Pharm. Pharmacol. 50 (4) (1998) 375–382, https://doi.org/10.1111/j.2042-7158.1998.tb06876.x.

[9] The Express Wire, Oral Solid Dosage Pharmaceutical Formulation Market Share, Size 2019 Global Growth, Opportunities, Trends, Regional Overview, Leading Company Analysis, and Key Country Forecast to 2025, The Express Wire, 2019. Retrieved April 1, 2020, from: https://www.theexpresswire.com/pressrelease/Oral-Solid-Dosage-Pharmaceutical-Formulation-Market-Size-Share-2019-Global-Industry-Trends-Segments-Competitors-Strategy-Regional-Analysis-Review-Key-Players-Profile-Statistics-and-Growth-to-2025-Analysis_104265.

[10] M.G. Teresk, C.J. Berkland, N.H. Dormer, Deficiencies in traditional oral dosage forms and the emergence of controlled-release powder manufacturing. KONA Powder Part. J. 2017 (34) (2017) 91–105, https://doi.org/10.14356/kona.2017013.

[11] U. Dunkan, N-(2-Hydroxypropyl) methacrylamide Copolymer Conjugates, in: G.S. Kwon (Ed.), Polymeric