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| Journal Name: | [**Asian Journal of Research in Medical and Pharmaceutical Sciences**](https://journalajrimps.com/index.php/AJRIMPS) |
| Manuscript Number: | **Ms\_AJRIMPS\_139129** |
| Title of the Manuscript: | **AI-Enhanced Process Analytical Technology for Real-Time Pharmaceutical Process Monitoring: A Review** |
| Type of the Article |  |

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| **PART 1: Comments** | | |
|  | **Reviewer’s comment**  **Artificial Intelligence (AI) generated or assisted review comments are strictly prohibited during peer review.** | **Author’s Feedback** (It is mandatory that authors should write his/her feedback here) |
| **Please write a few sentences regarding the importance of this manuscript for the scientific community. A minimum of 3-4 sentences may be required for this part.** | This manuscript offers a highly relevant and timely review on the integration of Artificial Intelligence (AI) with Process Analytical Technology (PAT) in pharmaceutical manufacturing. It addresses the increasing complexity of modern pharmaceutical production and illustrates how AI can optimize real-time process control and quality assurance. The review aggregates numerous case studies and scientific advances, particularly in the fields of solid dosage forms and biopharmaceuticals, demonstrating the operational and regulatory potential of AI-enhanced PAT. For the scientific community, especially those in pharmaceutical sciences, chemometrics, and regulatory affairs, this manuscript serves as a valuable consolidation of the state-of-the-art approaches in smart manufacturing. It also facilitates deeper understanding of continuous manufacturing and Quality by Design  (QbD) frameworks, which are critical for future-proofing the industry. |  |
| **Is the title of the article suitable?**  **(If not please suggest an alternative title)** | The current title, "AI-Enhanced Process Analytical Technology for Real-Time Pharmaceutical Process Monitoring: A Review", is clear, informative, and appropriately reflects the manuscript's content. However, it may benefit from minor revision for improved clarity and scholarly tone. A suggested alternative is "Integrating Artificial Intelligence with Process Analytical Technology for Real-Time Pharmaceutical Process Monitoring: A  Comprehensive Review". This version emphasizes the integration aspect and aligns with standard scientific review article titling practices. |  |
| **Is the abstract of the article comprehensive? Do you suggest the addition (or deletion) of some points in this section? Please write your suggestions here.** | The abstract provides a good overview of the manuscript, highlighting the role of AI in enhancing PAT, and touches on applications such as anomaly detection and quality monitoring. It also correctly emphasizes the benefits of combining AI and PAT in achieving Quality by Design. However, the abstract could be improved by including a brief mention of the specific pharmaceutical areas (e.g., solid dosage forms, biopharmaceuticals) and types of AI models (e.g., machine learning, deep learning) reviewed. This would give readers a clearer  expectation of the article’s scope and depth. |  |
| **Is the manuscript scientifically, correct? Please write here.** | The manuscript is scientifically accurate and well-supported by a rich body of references. It successfully explains the core principles of PAT and AI, and how their integration is operationalized in various real-world settings. The discussions are detailed and evidence-based, referencing specific studies with quantitative performance metrics where applicable. However, while the manuscript thoroughly covers the technical integration, a deeper discussion on the limitations or challenges of implementing such systems at scale (e.g., data privacy, regulatory hurdles,  model validation) would enhance its critical depth. |  |
| **Are the references sufficient and recent? If you have suggestions of additional references, please mention them in the review form.** | The references are generally recent, relevant, and sufficiently comprehensive, covering both foundational concepts and state-of-the-art developments in AI and PAT. Most citations are from high-impact journals published within the last five years, which reflects the rapidly evolving nature of this field. However, inclusion of a few additional references focused on regulatory perspectives from entities such as EMA or ICH on AI in manufacturing might provide a more rounded viewpoint. For instance:   * European Medicines Agency (EMA). "Reflection Paper on the Use of Artificial Intelligence (AI) in the Medicinal Product Lifecycle". 2023. [https://www.ema.europa.eu/en/news/reflection-paper-use-artificial-](https://www.ema.europa.eu/en/news/reflection-paper-use-artificial-intelligence-lifecycle-medicines) [intelligence-lifecycle-medicines](https://www.ema.europa.eu/en/news/reflection-paper-use-artificial-intelligence-lifecycle-medicines) * ICH E6(R3) Guideline on Good Clinical Practice – which includes sections on AI/ML in pharmaceutical development. <https://lifesciences.enago.com/blogs/the-role-of-ai-in-ich-e6-transforming-clinical-trials> |  |

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| **Is the language/English quality of the article suitable for scholarly communications?** | The language is mostly suitable for scholarly communication, and the manuscript is readable and professionally structured. However, minor grammatical issues and occasional awkward phrasing could benefit from proofreading by a native English speaker or professional editor. Examples include inconsistent punctuation and slightly colloquial expressions such as “tiny but unavoidable variations,” which could be better phrased as  “inherent minor variations.” Refinement would enhance the scholarly tone. |  |
| **Optional/General** comments | Overall, this manuscript is an informative and valuable contribution to the pharmaceutical science literature. It is particularly strong in its structured analysis of AI applications across various PAT use cases, supported by a broad and well-organized literature review. The visual elements (figures and tables) are generally helpful and relevant to the discussion. However, Figures 1, 2, 3, and Table 1 appear to have been adapted or reproduced from external sources, and they currently lack proper citation. It is important that the authors clearly indicate the source of these materials or confirm that they are original. To enhance the manuscript further, the following improvements are recommended:   * Provide a more critical discussion on the current challenges and future research directions in AI-enabled PAT. * Expand the discussion of regulatory implications arising from AI-PAT integration. * Refine the language throughout the manuscript to meet the highest standards of academic writing. |  |

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| **PART 2:** | | |
|  | **Reviewer’s comment** | **Author’s comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)* |
| **Are there ethical issues in this manuscript?** | *(If yes, Kindly please write down the ethical issues here in details)* |  |

**Reviewer details:**

**Parankush Koul, United States of America**