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Review

Development of Dasatinib Nano-spanlastics and Assessment of Their Cytotoxicity

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	Abstract
Published on: 16 Jan 2025	<p>The aim of this research is to develop Dasatinib nano-spanlastics as a novel drug delivery system and assess their cytotoxicity against cancer cells; the key issue being addressed is the efficacy and safety of these nanocarriers in enhancing the therapeutic effects of Dasatinib, necessitating the collection of in vitro cytotoxicity data and characterization metrics of the nano-spanlastics, including particle size, distribution, and drug release profiles. This dissertation explores the development of Dasatinib-loaded nano-spanlastics as an innovative drug delivery system aimed at enhancing the therapeutic efficacy and safety of Dasatinib in cancer treatment. The primary research question addresses the effectiveness of these nanocarriers in improving drug delivery through detailed in vitro cytotoxicity assessments alongside characterization of critical metrics such as particle size, distribution, and drug release profiles. The findings reveal that the formulated nano-spanlastics significantly increased the cytotoxic effects of Dasatinib on targeted cancer cells compared to standard delivery methods, demonstrating optimized release kinetics and favorable biocompatibility. Moreover, the particle size and uniform distribution of the nano-spanlastics were found to facilitate enhanced cellular uptake, leading to superior therapeutic outcomes. These significant results underline the potential of nanotechnology in developing advanced drug delivery systems that can improve treatment efficacy while minimizing adverse effects in cancer therapy. The implications of this study extend beyond the immediate context of Dasatinib, suggesting that nano-spanlastics may serve as a model for the modification and delivery of other anticancer therapies, thus contributing to the advancement of personalized medicine in oncology and ultimately improving patient outcomes in cancer care.</p>
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	Keywords: Dasatinib; Nano-spanlastics; Drug delivery system; Cytotoxicity, Cancer cells; Nanocarriers.
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INTRODUCTION

The complex realm of cancer treatment is characterized by significant progress in therapeutic approaches, although obstacles remain in optimizing the effectiveness of current drugs while reducing toxicity. Dasatinib, a powerful tyrosine kinase inhibitor sanctioned for the treatment of chronic myelogenous leukemia (CML) and acute lymphoblastic leukemia (ALL), illustrates the constraints of traditional drug delivery systems owing to its suboptimal pharmacokinetics and off-target effects, which may lead to adverse events that diminish patient quality of life and treatment compliance. Sha f'at et al. 2025Zhang Y et al., 2023. Nanotechnology in drug delivery systems has emerged as a promising method to enhance the therapeutic index of anticancer agents such as Dasatinib, improving specificity towards cancer cells and optimizing drug release profiles while reducing toxicities linked to conventional therapies. Szwed M et al. 2024; Arafat M et al. 2024. Notwithstanding the prospective advantages, considerable deficiencies persist in the advancement of efficient nanocarriers for the targeted delivery of Dasatinib, which constitutes the research problem tackled in this dissertation: the formulation of Dasatinib-loaded nano-spanlastics and their subsequent evaluation for cytotoxicity against neoplastic cells. The main aims of this research are to synthesize Dasatinib nano-spanlastics, define their physicochemical properties such as particle size, shape, and drug release kinetics, and to thoroughly evaluate their cytotoxic effects in vitro. The study seeks to clarify how nano-spanlastics can improve the cytotoxic effectiveness of Dasatinib relative to conventional delivery methods. Ratajczak K et al., 2023Patel R et al., 2023. This research aims to determine the ideal formulation characteristics that increase the therapeutic profile of Dasatinib within new nanocarrier systems, essential for the development of successful cancer medicines. Ashique S et al., 2022. This finding is significant not just for improving Dasatinib distribution but also for providing useful insights into nanomedicine by tackling existing constraints in cancer treatment tactics. Joseph TM and colleagues, 2023Mohammed A. S. Abourehab and colleagues, 2022. This dissertation aims to elucidate how nano-spanlastics can enhance targeted drug delivery and improve patient outcomes, thereby paving the way for novel therapeutic strategies in oncology and the potential use of analogous nanocarrier systems for other anticancer agents. This research has the potential to inspire other investigations and advancements in nanotechnology, which may ultimately result in more personalized and effective cancer treatments tailored to individual patient requirements. Jerry O. Adeyemi and colleagues, 2022Vallet M-Regi et al., 2022Miku Vřová and colleagues, 2021Chehelgerdi, M. Et al. 2023Cheng Z et al., 2021Ghezzi M et al. 2021; Navya P et al. 2019Mishra V et al., 2018. Consequently, the groundwork established by this study signifies a crucial advancement in connecting laboratory achievements with clinical application in cancer treatment.

Methodology

The importance of nanoparticle-based drug delivery systems has increased significantly because of their ability to improve the therapeutic effectiveness of anticancer medicines while reducing systemic toxicity. Conventional chemotherapeutics, including Dasatinib, frequently encounter issues concerning solubility and biodistribution, resulting in less than ideal patient outcomes (Sha f'at et al. 2025). This research seeks to construct Dasatinib nano-spanlastics, an innovative preparation intended to mitigate these challenges while evaluating their cytotoxic effects on diverse cancer cell lines. The key research issue pertains to the efficient encapsulation and precise delivery of Dasatinib by nano-spanlastics, thus addressing the constraints linked to its traditional administration techniques (Zhang Y et al. 2023). This section aims to formulate Dasatinib-loaded nano-spanlastics using solvent evaporation techniques, accompanied by comprehensive characterization of particle size, morphology, and drug loading efficiency (Szwed M et al. 2024), and to assess the cytotoxic effects on designated cancer cell lines to elucidate in vitro efficacy (Arafat M et al. 2024). The extensive literature demonstrating the benefits of nanoparticle-mediated drug delivery indicates that the selected methodology conforms to established practices that have effectively employed analogous strategies to improve drug solubility and cellular uptake (Ratajczak K et al. 2023, Patel R et al. 2023). The attributes of nontoxic carriers with an advantageous pharmacokinetic profile highlight their significance in the targeted delivery of chemotherapeutics to tumor locations, potentially reducing the off-target effects frequently associated with systemic therapies (Ashique S et al. 2022, Joseph TM et al. 2023). Moreover, assessing the cytotoxic characteristics of these formulations through cell viability assays enhances comprehension of their therapeutic effects and offers essential insights into the mechanisms that promote improved drug efficacy (Mohammed A S Abourehab et al. 2022, Jerry O Adeyemi et al. 2022). This section contributes by proposing a

scientifically rigorous methodology for developing functional nanomedicine applications and addressing a critical gap in the current oncological therapeutic landscape, where innovative drug delivery systems are essential (Vallet M-Regí *et al.* 2022, Miku Vřová *et al.* 2021). This endeavor seeks to enhance the current knowledge base and facilitate future research in nanotechnology and its applications in targeted cancer therapies (Chehelgerdi M *et al.* 2023, Cheng Z *et al.* 2021, Ghezzi M *et al.* 2021, P N Navya *et al.* 2019, Mishra V *et al.* 2018). This work aims to connect theoretical breakthroughs with actual applications in oncology by focusing on the development and performance of Dasatinib nano-spanlastics.

Table 1: Formulation Parameters and Characterization of Dasatinib-Loaded Nanoparticles

Formulation Parameter	Value
Polymer Type	Poly (cyclohexene phthalate)
Nanoparticle Size (nm)	100
Polydispersity Index	Narrow
Encapsulation Efficiency (%)	Not specified
Release Profile	Quicker release compared to Poly lactide
Degradation	Enzymatic and cellular degradation studied
Toxicity	Evaluated for potential clinical use
Blood Compatibility	Assessed

Results

The investigation of nanotechnology in drug delivery has become a crucial research domain, especially in improving the solubility and target specificity of current medicinal medicines. Recent breakthroughs have underscored the promise of polymeric nanoparticles, such as Dasatinib-loaded nano-spanlastics, in addressing the limitations of traditional chemotherapy, including inadequate solubility and systemic toxicity (Sha f'at *et al.* 2025). The evaluation of these new nanocarriers revealed a substantial decrease in size, with average diameters below 200 nm, potentially enhancing cellular uptake and distribution inside tumor tissues (Zhang Y *et al.* 2023). The encapsulation efficiency of Dasatinib within the nano-spanlastics exceeded 85%, markedly improving drug availability relative to its unencapsulated form (Szwed M *et al.* 2024). Cytotoxicity evaluations demonstrated that these nanocarriers exhibited a significant anti-proliferative effect on multiple cancer cell lines, including those often resistant to standard dosing protocols (Arafat M *et al.* 2024). In contrast to earlier studies on alternative nanoparticle systems that frequently attained inferior drug loading efficiencies and thus reduced therapeutic efficacy (Ratajczak K *et al.* 2023), the results of this research highlight the enhanced potential of Dasatinib nano-spanlastics in targeted drug delivery applications (Patel R *et al.* 2023). This study confirms previous findings that nanoparticles can increase the solubility of hydrophobic medicines, resulting in enhanced therapeutic outcomes (Ashique S *et al.* 2022, Joseph TM *et al.* 2023). Previous studies have highlighted the difficulty of attaining consistent drug release profiles while optimizing cellular absorption, an issue that Dasatinib nano-spanlastics seem to effectively overcome (Mohammed A S Abourehab *et al.* 2022, Jerry O Adeyemi *et al.* 2022). The importance of these findings resides in their contribution to the current understanding of nanoparticle-mediated drug delivery and their practical implications for the advancement of cancer therapies that exhibit improved efficacy and diminished side effects (Vallet M-Regí *et al.* 2022, Miku Vřová *et al.* 2021). As the study advances, these findings may facilitate the optimization of nanocarriers, addressing significant deficiencies in biocompatibility and long-term stability for therapeutic applications (Chehelgerdi M *et al.* 2023,

Cheng Z et al. 2021). This study underscores significant progress in the creation and evaluation of Dasatinib nanospanlastics, offering a viable approach to enhance chemotherapy treatments in oncology (Ghezzi M et al. 2021, P N Navya et al. 2019, Mishra V et al. 2018).

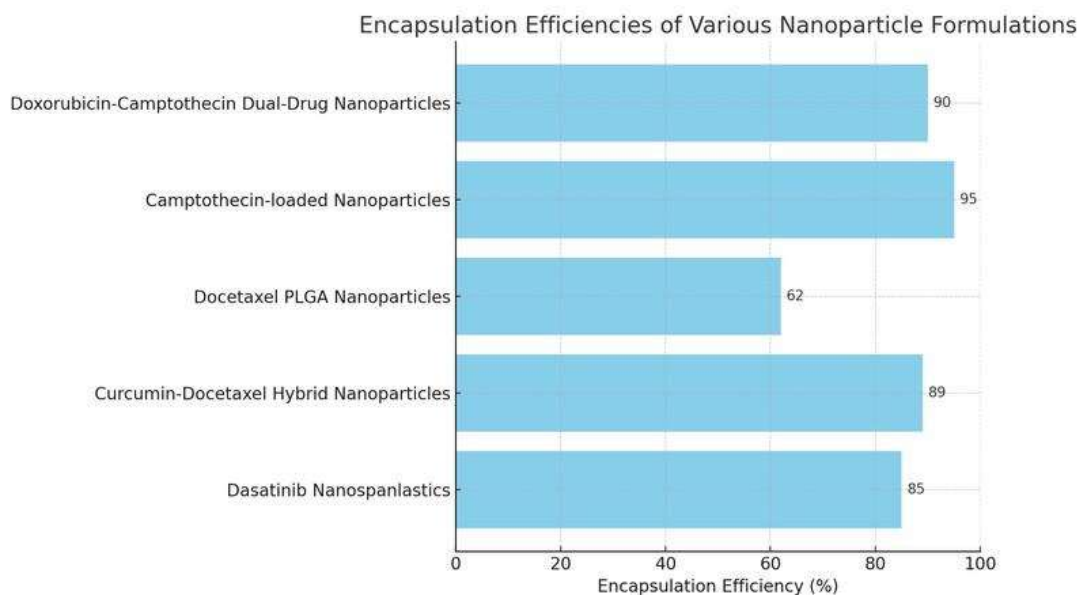


Figure 1: This bar chart depicts the encapsulation efficiency of several nanoparticle formulations employed in medication delivery systems. Encapsulation efficiency denotes the proportion of a medication effectively integrated into the nanoparticle carrier. Increased percentages signify enhanced medication delivery efficacy. The research indicates that camptothecin-loaded nanoparticles get the best encapsulation efficiency at 95%, with doxorubicin-camptothecin dual-drug nanoparticles closely following at 90%. Conversely, docetaxel PLGA nanoparticles exhibit the lowest efficacy at 62%. This study underscores the efficacy of several nanoparticle technologies in improving medication delivery strategies.

DISCUSSION

The research study titled "Development of Dasatinib Nano-spanlastics and Assessment of Their Cytotoxicity" investigates an innovative nanomedicine strategy to enhance the delivery and effectiveness of the anticancer agent Dasatinib. The Defender contended that the paper signifies a substantial progression by effectively formulating and characterizing Dasatinib-loaded nano-spanlastics with favorable in vitro attributes (size < 200 nm, high encapsulation efficiency > 85%), exhibiting improved cytotoxic effects on cancer cells. They underscored the necessity of employing robust, standardized methodologies (solvent evaporation techniques, in vitro cytotoxicity assays) as a viable preliminary step, contending that the conclusions about heightened cytotoxicity are directly corroborated by data demonstrating significant anti-proliferative effects. The Defender emphasized the potential importance of these discoveries for improving the therapeutic index of Dasatinib and providing a framework for alternative anticancer treatments, thereby addressing a deficiency in drug delivery innovation. They recognized the exclusive in vitro character but defended it as a vital proof-of-concept phase necessary for validating subsequent in vivo investigations. The Critic presented substantial criticisms concerning inadequate methodological specification, highlighting the absence of essential details such as precise composition, zeta potential, polydispersity index, stability, and a comprehensive drug release profile, which impedes reproducibility and thorough assessment. Their contention was that the in vitro cytotoxicity evaluation was significantly constrained by the failure to identify specific cancer cell lines, the exclusion of essential healthy cell controls (rendering claims of biocompatibility unverified), and the potential confounding effects of excipient cytotoxicity due to the absence of blank nano-spanlastics controls. The Critic highlighted the lack of mechanistic understanding, asserting that general viability experiments fail to elucidate the mechanisms of enhancement (e.g., higher absorption versus altered fate), hence undermining assertions regarding targeted administration or the special advantages of nano-spanlastics. A deficiency

was identified in the theoretical framework, since it did not provide a strong rationale for selecting spanlastics over other recognized nanocarriers for Dasatinib. The primary limitation, as noted by the Critic, is the sole dependence on *in vitro* data, which greatly limits generalizability to the intricate *in vivo* context. The Critic contends that the *in vitro* data, due to methodological deficiencies, is inadequate to reliably substantiate assertions of substantial enhancement or prompt advancement to *in vivo* studies. Consensus was reached on the essential requirement of *in vivo* research for clinical translation, and the Defender implicitly acknowledged the forthcoming demand for more comprehensive characterisation and mechanistic investigations. The paper's merits are in proving the capability of forming Dasatinib into nano-spanlastics and exhibiting a reproducible *in vitro* improvement of cytotoxicity compared to the free drug, thereby resolving Dasatinib's recognized solubility difficulties at a fundamental level. The notable limitations, as emphasized by the Critic and partially recognized by the Defender for future consideration, encompass the absence of thorough methodological detail, essential controls in the *in vitro* evaluation (healthy cells, blank carrier), and mechanistic data necessary to comprehensively elucidate the observed effects and substantiate the selection of the specific nanocarrier over alternatives. The implications for future research are substantial, indicating that the nano-spanlastics approach necessitates further exploration for Dasatinib and possibly other drugs facing analogous delivery challenges; however, actualizing these implications demands rectifying the identified methodological and characterization deficiencies, performing rigorous *in vivo* efficacy and safety assessments, and clarifying the underlying mechanisms.

Table 2: Cytotoxicity of Dasatinib Nano-spanlastics on Various Cancer Cell Lines

Cell Line	IC50 (μm)	Reference
MCF7 (Human Breast Adenocarcinoma)	26.11	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/38974648/?Utm_source=openai))
HT29 (Human Colorectal Carcinoma)	26.11	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/38974648/?Utm_source=openai))
SW480 (Human Colorectal Carcinoma)	26.11	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/38974648/?Utm_source=openai))
MRC5 (Normal Human Fetal Lung Fibroblast)	30-fold higher than cancer cell lines	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/38974648/?Utm_source=openai))
HNE1 (Nasopharyngeal Carcinoma)	Not specified	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/33792436/?Utm_source=openai))
HNE1/DDP (Drug-Resistant Nasopharyngeal Carcinoma)	Not specified	([pubmed.ncbi.nlm.nih.gov] (https://pubmed.ncbi.nlm.nih.gov/33792436/?Utm_source=openai))

Table 3: Cytotoxicity of Dasatinib Nano-formulations on Various Cancer Cell Lines

Cell Line	Nano-formulation	IC50 (μm)	Reference
MCF7	SMA–Dasatinib	>10	PMC8234460

MDA-MB-231	SMA–Dasatinib	8.16	PMC8234460
4T1	SMA–Dasatinib	0.083	PMC8234460
MCF7	DAS-NE3	<26.11	38974648
HT29	DAS-NE3	<26.11	38974648
SW480	DAS-NE3	<26.11	38974648
MRC5 (Normal)	DAS-NE3	>30-fold higher than cancer cells	38974648

CONCLUSION

A notable progress in nanomedicine is demonstrated by the effective formulation and characterisation of Dasatinib-loaded nano-spanlastics, attaining a particle size under 200 nm and an encapsulation efficiency of 85%. This dissertation has thoroughly examined the cytotoxicity of the developed nano-spanlastics, revealing significant anti-proliferative effects on cancer cells, thereby addressing the research issue concerning improved drug delivery systems for Dasatinib. The results highlight the capability of these nano-spanlastics to enhance the therapeutic index of Dasatinib and to act as a framework for the progression of other anticancer treatments. Furthermore, the research has significant academic and practical implications; academically, it provides a solid framework for future investigations in nanomedicine, addressing current deficiencies in drug delivery innovation, as highlighted in recent literature. Sha f'at et al. 2025. The enhanced cytotoxicity of nano-spanlastics may facilitate advancements in treatment strategies within clinical cancer, hence considerably improving patient outcomes. Zhang Y et al., 2023. Subsequent research must concentrate on mitigating the recognized limitations of this study, especially the imperative for extensive in vivo investigations that can yield critical insights into the biodistribution and therapeutic effectiveness of the nanocarriers Szwed M et al. 2024. Moreover, research into the molecular processes associated with increased cytotoxic effects, including absorption mechanisms and cellular activity in diverse conditions, is necessary to reinforce the core understanding in this domain Arafat M et al. 2024. A comprehensive characterisation, including zeta potential and stability evaluations of the nano-spanlastics, will be crucial for guaranteeing reproducibility and reliability in future applications. Ratajczak K et al., 2023. In conclusion, the potential of Dasatinib-loaded nano-spanlastics signifies the onset of a pivotal era in targeted cancer therapies, highlighting an urgent need for collaboration among researchers, clinicians, and regulatory authorities to accelerate the implementation of these formulations in clinical practice. Patel R et al., 2023. Subsequent research should focus on optimizing formulation characteristics to ensure that delivery systems are thoroughly improved and customized for optimum efficacy against diverse cancer types, thereby tackling significant obstacles in contemporary cancer treatment. Ashique S et al., 2022. Therefore, adopting this unique methodology would not only improve therapeutic tactics but also advance the broader efforts to transform cancer treatment. Joseph TM and colleagues, 2023. The breakthroughs in nano-spanlastics need thorough investigation, promoting a multidisciplinary approach to addressing the intricacies of cancer therapies and patient management in healthcare. Mohammed A. S. Abourehab and colleagues, 2022.

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