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Marine Algae Mediated Silver Nanoparticles – Cyclodextrin Encapsulation For Improved Anticancer Application

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Abstract: *Dictyota dichotoma* and *Sargassum*, marine brown algae, were harvested from the coastal waters of Idinthakarai in the Tirunelveli district from which the nanoparticles were synthesized (DDA & SAA). They were used to refine α-cyclodextrin (α-CD) inclusion complexes to improve their stability and therapeutic effectiveness. The successful formation of these complexes (DDA: α-CD & SAA: α-CD) was validated through ^{1}H NMR spectroscopy, where distinct chemical shift variations confirmed host–guest interactions within the cyclodextrin cavity. The inclusion complexes showed significantly better anticancer capability than the free nanoparticles, as indicated by lower IC_{50} values and improved growth inhibition at higher concentrations, when cytotoxic activity was evaluated against K562 leukaemia cells. These findings demonstrate the synergistic benefit of α-CD encapsulation in enhancing the biological activity and bioavailability of nanoparticles generated from algae. All things considered, this research highlights the potential of cyclodextrin-based nanocomplexes and marine algae resources as long-term platforms for the creation of potent anticancer drugs.

Keywords: Marine algae, Inclusion complexes, ^{1}H NMR, α-cyclodextrin, Anticancer.

1.Introduction

Cancer remains an ongoing risk to world health, with haematological malignancies such as leukaemia providing considerable therapeutic problems owing to their complexity and resilience to traditional therapy. Uncontrolled growth of aberrant white blood cells, which disrupts normal haematopoiesis and immunological function, is a hallmark of leukaemia. Its increasing prevalence in both adult and paediatric populations highlight the need for novel, effective, and targeted therapy approaches[1]. The investigation of nanotechnology in cancer is motivated by the persistence of

problems including systemic toxicity, lack of solubility, and resistant to multiple drugs despite advancements in chemotherapeutics and targeted medicines.

Since nanomaterials can be molecularly designed for improved drug transport, controlled release, and tumor-specific targeting, nanotechnology presents intriguing treatment options for cancer[2]. Due to their capacity to cause oxidative stress and interfere with biological processes, metallic nanoparticles particularly silver nanoparticles have drawn notice for their inherent lethal qualities against cancer cells, including leukemic cell lines[3]. However, stability, aggregation, and biocompatibility issues frequently hinder the use of nanoparticles in biomedicine.

Cyclodextrins and other biocompatible host molecules have been suggested as a solution to these problems. The cyclic oligosaccharide α-Cyclodextrin (α-CD) is noteworthy for its capacity to create inclusion complexes with hydrophobic guest molecules, which enhances its stability, bioavailability, and water solubility[4]. α-CD can encapsulate surface-bound or related bioactive compounds when paired with nanoparticles, providing a synergistic platform for controlled release and drug administration.

A unique approach to improving the dispersion, functionalisation, and therapeutic effectiveness of nano systems is the formation of inclusion complex between α-CD and silver nanoparticle. These complexes are good candidates for leukaemia treatment because they may increase cellular absorption and prevent off-target effects. Thus, the combination of supramolecular chemistry with nanotechnology opens up new possibilities for the development of intelligent anticancer systems. This involves the study of Anticancer activity of α-CD inclusion complexes (DDA: α-CD & SAA: α-CD) synthesized from the prepared silver nanoparticles (DDA & SAA) from the marine algae *Dictyota dichotoma* and *Sargassum* respectively.

2.Materials and Methods

2.1 Collection and Preparation of Marine algae extracts

Dictyota dichotoma and *Sargassum*, marine brown algae, were collected from the Idinthakarai coastal waters in the Tirunelveli district. The obtained algae specimen was initially rinsed with seawater to eliminate surface contaminants, epiphytes, and related marine creatures. A series of washes with double-distilled water were then performed to get rid of any leftover impurities. The cleaned sample were then shade-dried and ground into a fine powder. A determined quantity (5 g) of the powdered biomass was treated to water extraction using a Soxhlet device for 8 hours. The resulting crude extracts of each alga, enriched with bioactive metabolites, were collected and stored under appropriate conditions for further use.

2.2 Green synthesis of silver nanoparticles

Silver nanoparticles were synthesized by mixing 1 mM silver nitrate ($AgNO_3$) with algae extract of *Dictyota dichotoma* and Sargassum separately in an 8:2 ratio. After being gently mixed, the mixtures were allowed to adjust to room temperature in the dark. The generation of nanoparticles were suggested by a colour shift from pale yellow to dark brown, which UV-visible spectroscopy further validated. Because of their algal origins, the resultant nanoparticles were given the name DDA & SAA

(Nanoparticle derived from *Dictyota dichotoma* & *Sargassum* respectively).

2.3 Formulation of α-CD Inclusion Complexes

The preparation of the inclusion complex DDA: α-CD involved dissolving 0.035 g of the DDA nanoparticle in 25 mL of deionised water and mixing it with a different solution that contained 0.300 g of α-CD in 25 mL of deionised water. To promote host-guest interaction and complex formation, the combined mixture was kept at room temperature for 4 days while being agitated periodically. After finishing, the solvent was let to evaporate in the open air, and the solid inclusion complex was obtained by oven-drying the resultant material. For later characterisation, the dried inclusion complex was properly preserved. The same procedure was followed for the preparation SAA: α-CD with SAA (Silver nano).

2.4 Study of Cytotoxicity using MTT Assay

The anticancer potential of α-CD based inclusion complexes against the K562 leukaemia cell line was assessed using the colorimetric MTT test. This technique uses mitochondrial enzymatic reduction activity to evaluate cell viability. The concentration needed to stop 50% of cell growth was found by calculating the IC_{50} value. A linear regression equation ($y = mx + c$) was generated from the plotting of absorbance values corresponding to different concentrations of the test materials using Microsoft Excel in order to precisely compute the IC_{50}.

3. Result and Discussion

3.1 ^{1}H NMR Spectroscopic Characterization

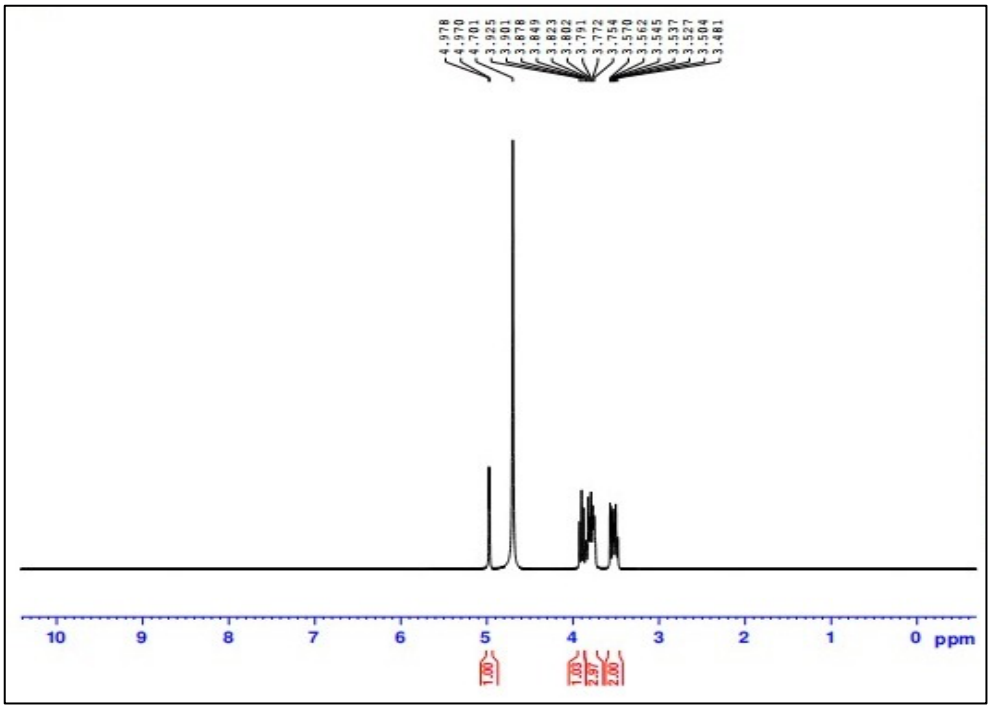


Fig. 1 (a) ^{1}H NMR spectrum of α-CD

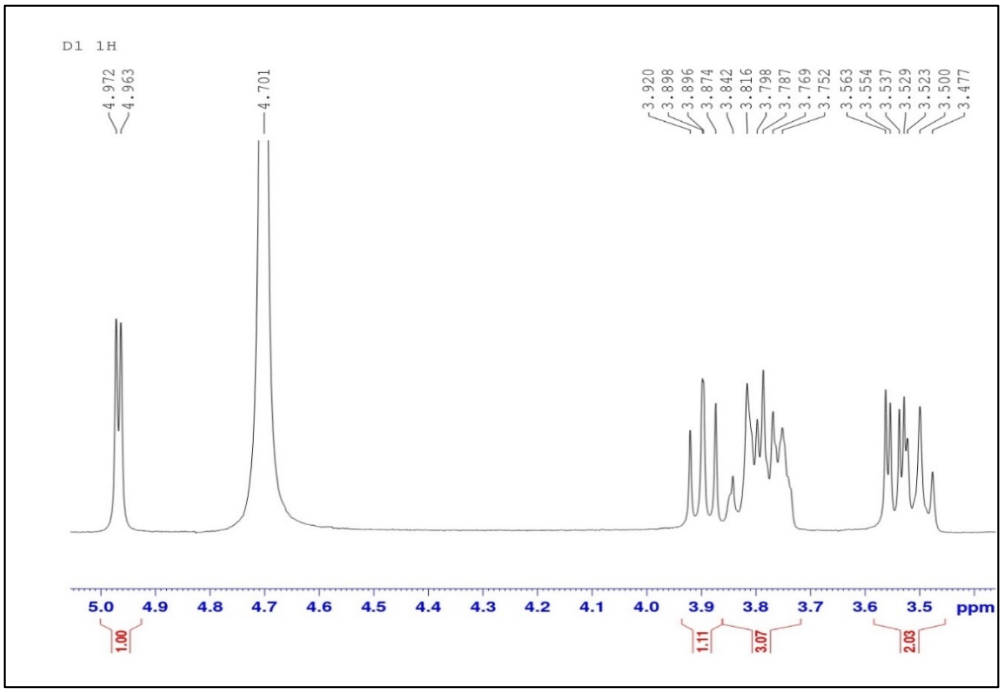


Fig. 1 (b) ^{1}H NMR spectrum of DDA: α-CD

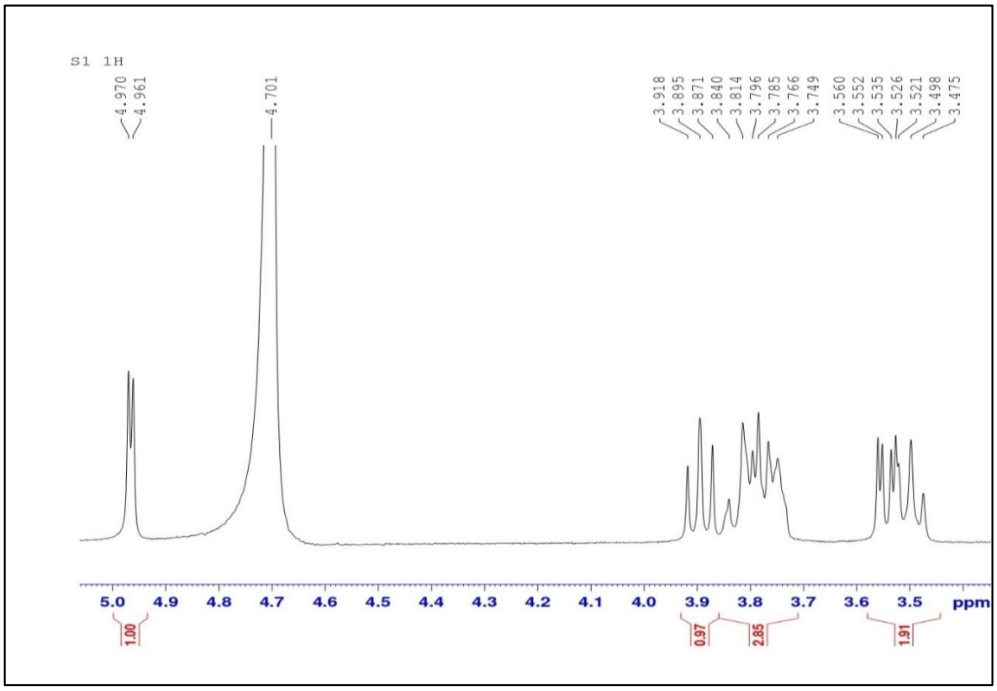


Fig. 1 (c) ^{1}H NMR spectrum of SAA: α-CD

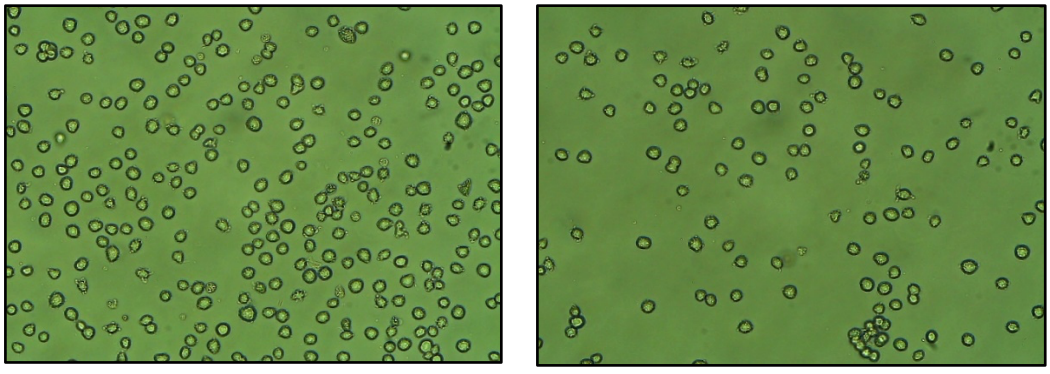
Table 1. ^{1}H NMR spectral shifts in DDA: α-CD & SAA: α-CD with α-CD

Proton	Inclusion complexes	Shift values	α-CD	δ

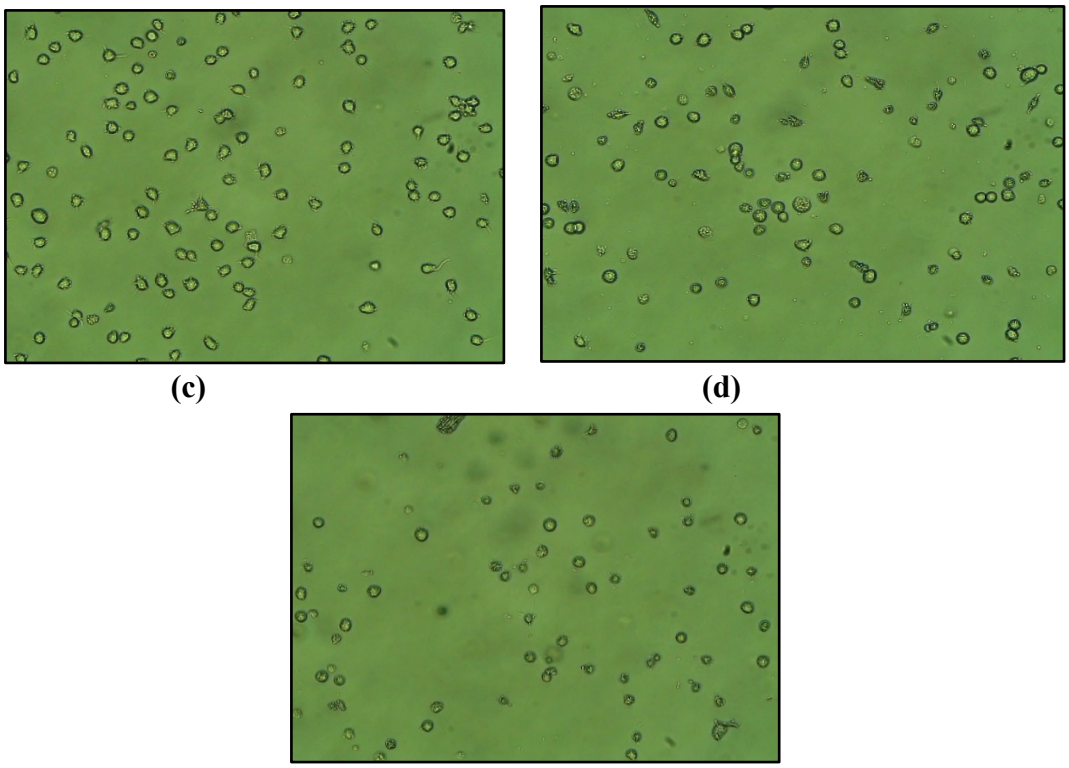
H1	**DDA: α-CD**	4.972	4.978	0.006
	SAA: α-CD	4.970	4.970	0
H2	**DDA: α-CD**	3.500	3.504	0.004
	SAA: α-CD	-	-	-
H3	**DDA: α-CD**	3.816	3.823	0.007
	SAA: α-CD	3.840	3.849	0.009
H4	**DDA: α-CD**	3.477	3.481	0.004
	SAA: α-CD	-	-	-
H5	**DDA: α-CD**	3.563	3.570	0.007
	SAA: α-CD	3.535	3.545	0.010
H6	**DDA: α-CD**	-	-	-
	SAA: α-CD	3.475	3.481	0.006

Fig. 1 (a), (b), (c) and Table. 1 were the ^{1}H NMR spectrum of α-CD, DDA: α-CD, SAA: α-CD and ^{1}H NMR spectral shifts respectively. The formation of inclusion complexes between *Dictyota dichotoma* (DDA) and α-cyclodextrin (α-CD), as well as *Sargassum* (SAA) and α-CD, was confirmed by the observed changes in the chemical shift (Δδ) values of α-CD protons in the ^{1}H NMR spectra. Even small variations in the proton environment, particularly for H1–H6, indicate alterations in the electronic surroundings due to the guest molecules being accommodated within the hydrophobic cavity of α-CD. For DDA: α-CD, measurable downfield and upfield shifts (Δδ = 0.004–0.007 ppm) are noted for H1, H2, H3, H4, and H5 protons, suggesting significant host–guest interactions. Similarly, in SAA: α-CD, shifts are evident for H3, H5, and H6 protons (Δδ = 0.006–0.010 ppm), which further confirm the encapsulation of the guest molecules into the α-CD cavity. These spectral perturbations are characteristic markers of successful inclusion complex formation.

3.2 Anticancer activity of the Inclusion complexes



(a) **(b)**



(c) **(d)**

(e)

Fig. 2 Cytotoxic Evaluation of DDA: α-CD at Graded Concentrations (a) 10 µg/mL (b) 20 µg/mL (c) 40 µg/mL (d) 80 µg/mL (e)160 µg/mL

Table 2 Evaluation of Cytotoxic Effect of DDA: α-CD in K562 Cells

Reaction Settings	**Cell Viability Rate**	**IC_{50} (ug/ml)**
Non-treated	100.00	**23.22**
Std. Reference	45.26	
10ug	62.17	
20ug	57.96	
40ug	43.89	
80ug	29.35	
160ug	4.06	

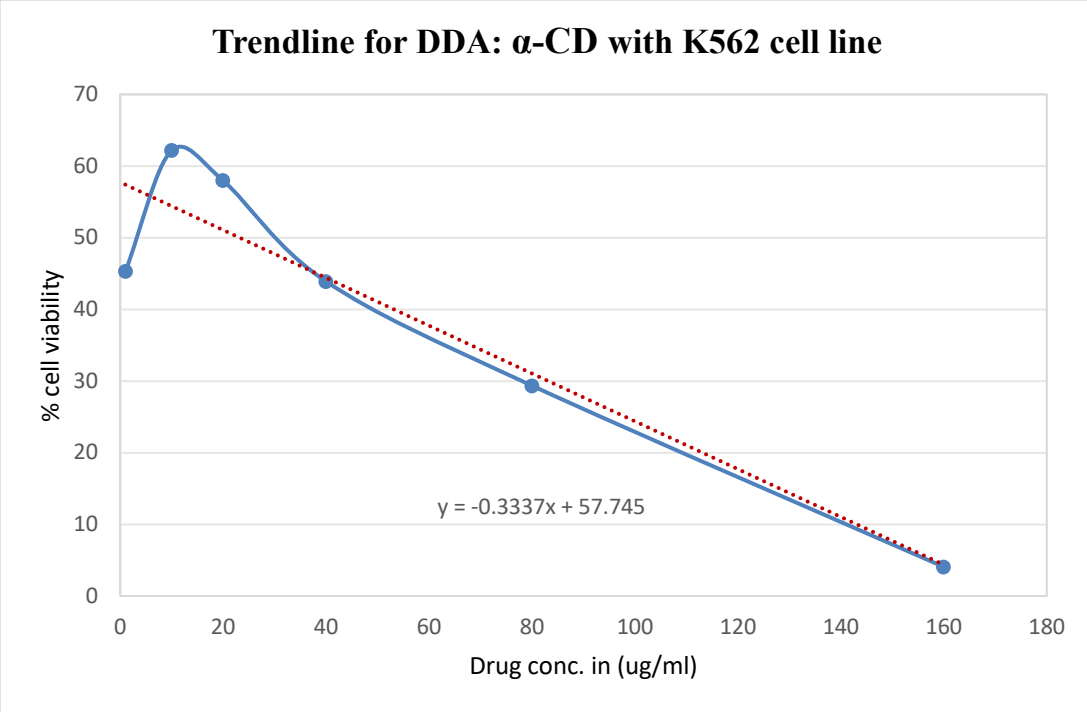
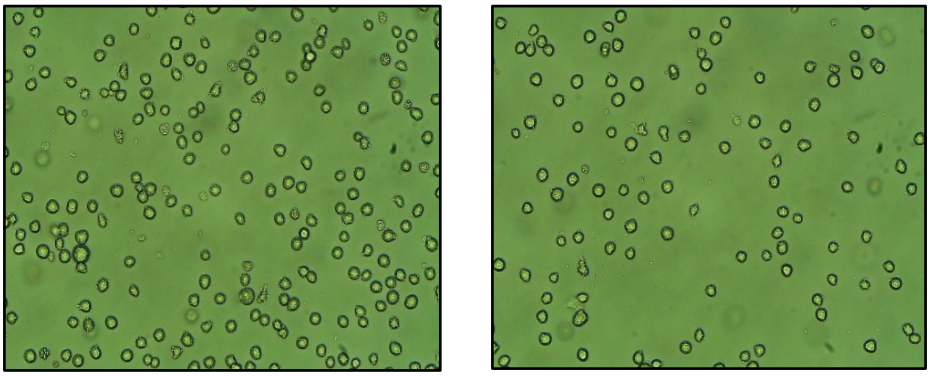
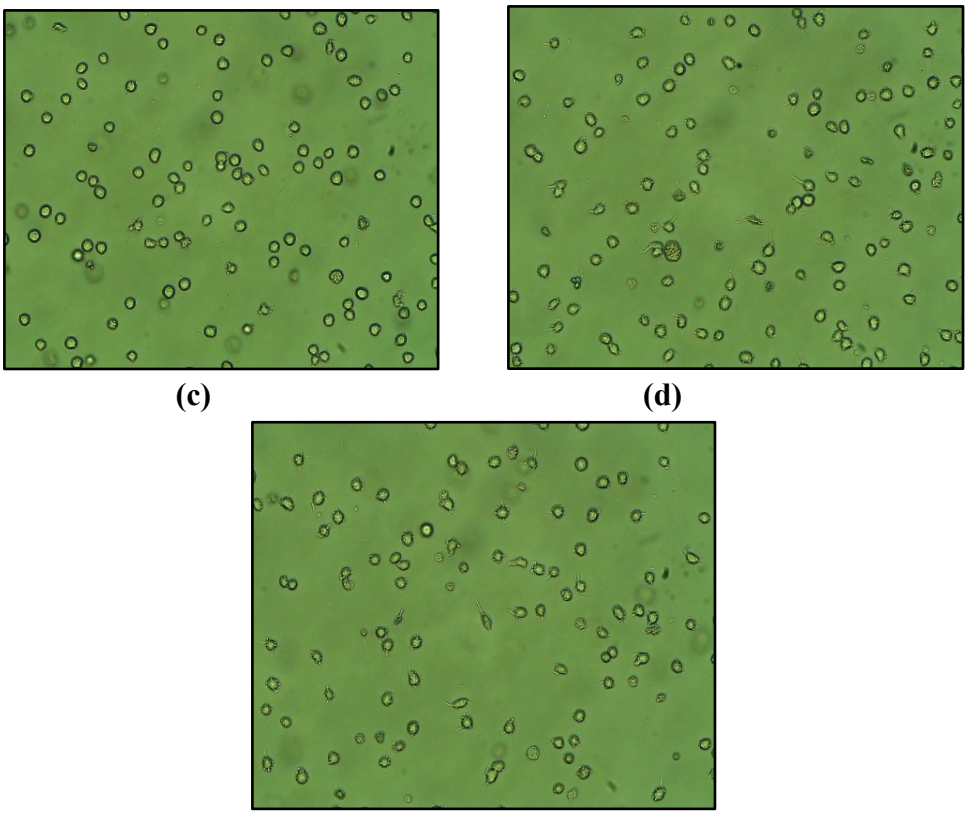


Fig. 3 Trendline representation of DDA: α-CD induced cytotoxicity in K562 cell

The DDA: α-CD inclusion complex cytotoxicity effect in K562 cells is showed in Table.2, Fig 2 and Fig.3 revealed a significant decrease in cell viability, with an IC_{50} value of 23.22 µg/ml and only 4.06% survival at the highest tested dosage (160 µg/ml). On the other hand, free DDA showed a significantly larger IC_{50} of 94.69 µg/ml and maintained 18.76% viability at 160 µg/ml, indicating a somewhat lesser effect. This study unequivocally shows that DDA's cytotoxic effectiveness against K562 cells is greatly increased upon complexation with α-CD, most likely as a result of enhanced solubility and bioavailability.



(a) **(b)**



(c) **(d)**

(e)

Fig. 4 Cytotoxic Evaluation of SAA: α-CD at Graded Concentrations (a) 10 µg/mL (b) 20 µg/mL (c) 40 µg/mL (d) 80 µg/mL (e)160 µg/mL

Table 3 Evaluation of Cytotoxic Effect of SAA: α-CD in K562 Cells

Reaction Settings	Cell Viability Rate	IC_{50} (ug/ml)
Non-treated	100.00	**27**
Std. Reference	45.26	
S_1-10ug	62.12	
S_1-20ug	42.68	
S_1-40ug	29.14	
S_1-80ug	13.65	
S_1-160ug	4.79	

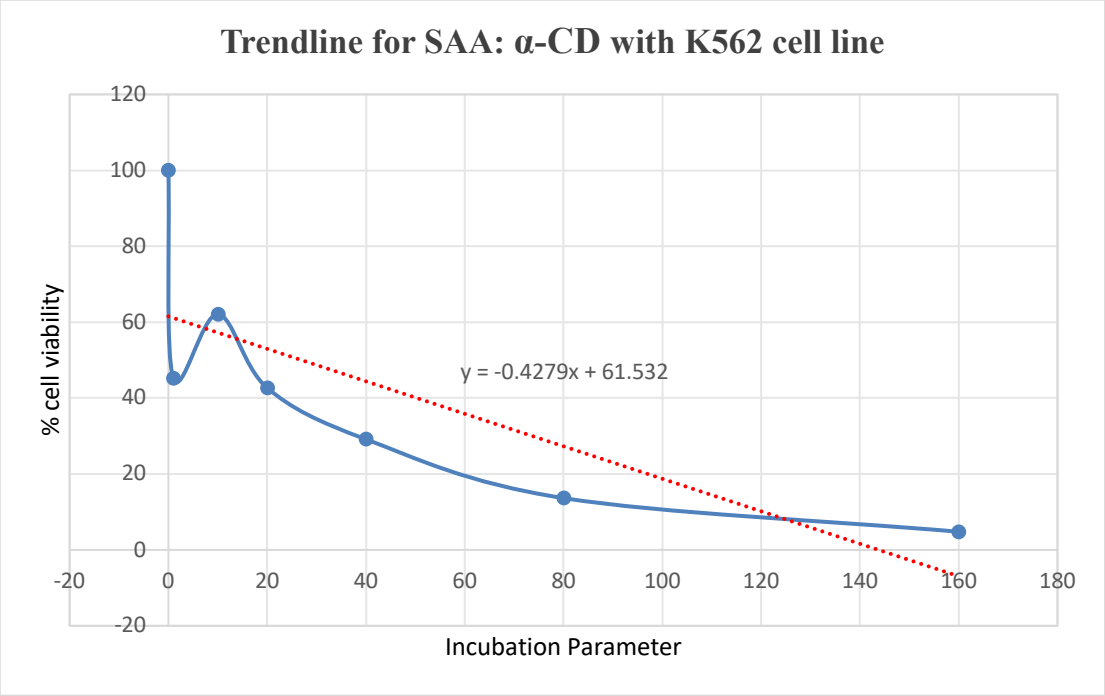


Fig. 5 Trendline representation of SAA: α-CD induced cytotoxicity in K562 cell

The SAA: α-CD inclusion complex demonstrated a strong inhibitory effect on K562 cells in the cytotoxic evaluation; at 160 µg/ml, cell viability dropped to just 4.79%, and the IC_{50} was 27 µg/ml. On the other hand, free SAA nanoparticles showed a much higher IC_{50} of 79.34 µg/ml and maintained greater viability (8.01%) at the same dose. This obvious difference highlights how α-CD encapsulation greatly increases SAA's cytotoxic efficacy, most likely by improving its molecular stability, cellular internalisation, and water solubility.

Conclusion

Sargassum and *Dictyota dichotoma*, two marine brown algae that were gathered from the coastal waters of Idinthakarai in the Tirunelveli district, were effectively used for the environmentally friendly production of nanoparticles. These nanoparticles were then used to create α-cyclodextrin inclusion complexes, which were verified by ^{1}H NMR using distinctive changes in chemical shift. The inclusion complexes demonstrated significantly higher anticancer activity than the free nanoparticles, according to cytotoxic evaluation against K562 cells. Overall, this study shows that cyclodextrin–nanoparticle complexes produced from algae have the potential to be effective and long-lasting anticancer agents.

Reference

1. Seyyednia, E., Oroojalian, F., Baradaran, B., Mojarrad, J.S., Mokhtarzadeh, A., Valizadeh & H 2021, 'Nanoparticles modified with vasculature-homing peptides for targeted cancer therapy and angiogenesis imaging', *J. Control. Release*, vol. 338, pp. 367–393.

2. Sriram, M. I., Kalishwaralal, K., Barathmanikanth, S., & Gurunathan, S 2020, Antitumor activity of silver nanoparticles in Dalton's lymphoma ascites tumor model. *International Journal of Nanomedicine*, Vol. 15, pp. 1339–1355.
3. Wang, Y., Xie, Y., Kilchrist, K. V., & Duvall, C. L 2022, Nanomedicine strategies for treatment of leukemia. *Advanced Drug Delivery Reviews*, Vol. 183, pp. 114150.
4. Loftsson, T., & Duchêne, D 2007, Cyclodextrins and their pharmaceutical applications. *International Journal of Pharmaceutics*, Vol. 329, pp. 1–11.