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ARTICLE

Catalytic application of non-toxic *Persia americana* metabolite entrapped SnO_2 nanoparticles towards the synthesis of 3,4-dihydroacridin-1(2*H*)-ones

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An Eco friendly method in organic synthesis plays a dynamic prerequisite for environmental safety. In general, metal nanoparticles displayed various roles towards toxicity, photo catalytic activity and catalytic activities. Due to its diverse properties, recent work has been focused towards the exploitation of plant sources in nanoparticle synthesis. Herewith, we have highlighted the non-toxic studies of green synthesized SnO_2 nanoparticles (SnO_2 NPs) using *Persia americana* seed. The catalytic effect SnO_2 NPs were investigated on the synthesis of 3,4-dihydroacridin-1(2*H*)-ones. Synthesized compounds were confirmed using ^{1}H NMR, ^{13}C NMR and LCMS analysis. We proved SnO_2 NPs are non-toxic towards aquatic organism.

Introduction

Throughout the globe, recently one of the major threat that was faced is said to be environmental pollutants which causes an adverse effects on human health. [1] Several organic pollutants were disposed directly to the environment from pharmaceutical, chemical and textile industries. [1] These exposion type of organic toxic effulents leads to severe damge cause over environmental retardation. To over come these toxic effulents most of the researchers focused towards nanoparticles synthesis by various methodology which helps in catalytic reactions. Nanotechnology was one of the rapid growing fields among the various interdisciplinary sciences. Eventhough it shows potent applications, nanomaterials have high negative impact on human health and environment.[1] It was identified that metal nanoparticles exposed to the environment after the utilization. These airborne metals may settle in environment for longer duration. It may cause short and long time effects to the environment and human health. [2,3] Metal oxide nanoparticles are small in size but has lagre surface, hence it can be easily bind to the toxic chemical surface and transport the toxic chemical pollutants. [4,5] The SnO_2 NPs have wide application various fields but it has its own disadvantage of inducing acute toxic effects. The SnO_2 NPs through inhalation may irritate the upper resperiratory tract, skin and eyes. When SnO_2 NPs binds to metal like indium it causes adverse effects on human health such as chronic toxicity, [6] Pulmonary toxicity, [7] Testicular toxicity, [8] etc., Though metal oxide nanoparticles were utilized in various applicational fields such as solid state gas sensor, solar cells, rechargeable Li batteries and optical electronic devices. [9,10] The SnO_2 NPs has been consider as one of the best photo catalysts with n- type of tetragonal crystal structure with a band gap of around 3.6 eV. [11] Several methods have been adopted for the synthesis of SnO_2 NPs such as sol-gel process, spray pyrolysis, solvo-thermal, micro emulsion, homogenous precipitation, sono-chemical, polymerized complex citrate route and non-aqueous approaches. [12-14] But these methods leads to some toxic effects to the environment and human health due to the effect of usage of toxic solvents and chemicals.[15-17] Various biological heterocycles have been reported with chemical method but it may be toxic. [18] To overcome these toxicity effects we have focused our research towards the environment friendly synthesis of SnO_2 NPs using *Persia americana* seed methonalic extract Further, we have subjected to organic synthesis i.e., SnO_2 nanoparticles catalysed synthesis of 3,4-dihydroacridin-1(2*H*)-ones under solvent free conditions.

Results and Discussion

The percentage natality in test and control of the surveying nauplii was counted after 24 h with the aid of 3X magnifying glass. The LC_{50} values of the tests were obtained from best fit-line plotted graph plotted between the concentrations versus percentage natality. The statistical data was obtained from natality percentage and survival nauplii by this best fit line method using origin software was clearly illustrated in (Fig. 1).

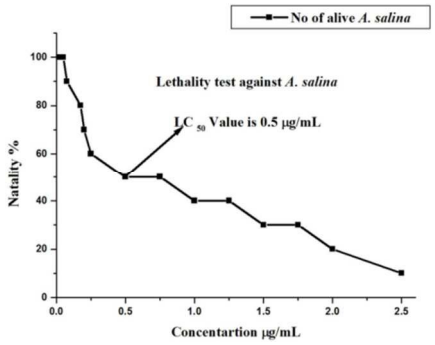


Fig 1. Toxicity profiling of SnO_2 NPs against *A. salina*

By using the graph, we have obtained an interesting result that the LC_{50} value which is less than 0.5 µg/mL which supported the green synthesized SnO_2 NPs with less toxic effects on the aquatic species. To optimize the effect of SnO_2 NPs in organic synthesis we have subjected various amount of catalyst (0, 5, 10, 15, 20 mole %). When the reaction has been carried out in absence of catalyst unfortunately we found the yield of the reaction is very low of 22 % (Table 1).

Table 1. Optimization of amount of SnO_2 NPs for the synthesis of compound, **3a**

Sl.No	Solvents	Time (min)	Isolated yield (%)
1	MeOH	120	84
2	DCM	60	64
3	Chloroform	60	71
4	Toluene	120	81
5	Water	120	70
6	No solvent	15 min	93

Effect of solvent for the synthesis of 7-nitro-9-phenyl-3,4-dihydroacridin-1(2*H*)-one **3a** was employed (Table 2, Fig. 2).

Table 2. Effect of solvent for the synthesis of compound, **3a**

Catalyst loading (mol %)	0	5	10	15	20
Isolated Yield (%)	22	56	93	92	90

Among these, the solvent free conditions provided about 93 % isolated yield when compared to other settings. We also found that the optimized quantity of catalyst for the formation of the product **3a** is 10 mole percentages. By fine-tuned reaction conditions, we have synthesized successfully seven acridone analogues with good to excellent yield ratio.

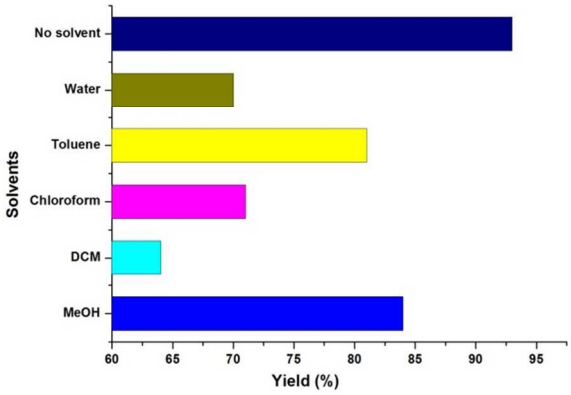


Fig 2. Effect of Solvent

The synthesized compounds were confirmed using ^{1}H NMR, ^{13}C NMR and LCMS analysis. In the ^{1}H NMR spectra of the compound **3a**, there is one quartet in the range from δ 2.28 – 2.34 and it corresponds to H-3 (one -CH_2). Two triplets are appears at δ 2.77 and 3.45 which was assigned for H-2 and H-4 respectively. Then 8 aromatic protons are appears in the range of δ 7.19 – 8.54. In the ^{13}C NMR spectrum of compound, **3a** there are 3 signals at δ 21.0, 34.8, and 40.4 are assigned for C-03, C-04, and C-02 respectively. The signal δ 197.0 is assigned for C-1 (Carbonyl carbon). The remaining signal are corresponds to 15 aromatic carbons which includes both protonated and non-protonated carbons. Catalyst has been reused for several times there is not significant variation in the yield. It clearly shows catalyst can be used as multiple times (Fig. 3).

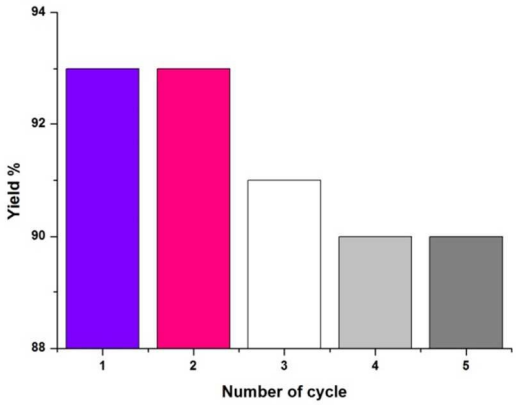


Fig 3. Reusability of the SnO_2 NPs

Conclusion

The SnO_2 NPs was synthesized using *Persia americana* methanolic extract seed without introducing any toxic elements to the environment and also it said to be one of the cheapest methods for synthesis of SnO_2 nanoparticles. The synthesized SnO_2 NPs were characterized by UV, XRD, and TEM. The SnO_2 NPs provides the promising result towards organic synthesis of 3,4-dihydroacridin-1(2*H*)-ones, **3(a-g)** under solvent free conditions. The synthesized compounds were purified by without column chromatographic technics.

Experimental section

Synthesis of SnO_2 NPs

The preparation of SnO_2 NPs was achieved using *Persia americana* as a green source. The synthesised SnO_2 NPs were characterised by UV, XRD, and SEM are reported in our earlier report.[19] The green synthesis of SnO_2 NPs was illustrated in Fig 4.

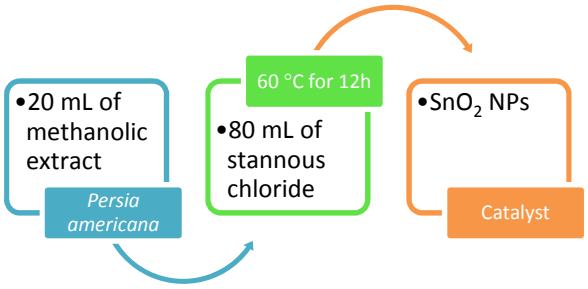


Fig 4. Eco-friendly synthesis of SnO_2 nanoparticles

Toxicity studies

For the toxicity assays the samples were prepared with the overall concentration of 500 µg/ mL by mixing 10 mg/mL stock solution of SnO_2 NPs and 19 mL of sea water. The experimental process were done by using 6 well plate technique which contains various concentrations like 2.5, 2, 1.75, 1.5, 1.25, 1, 0.75, 0.5, 0.25, 0.2, 0.175, 0.075, 0.05, 0.025 µg/ mL and blank has 5 mL of sea water with 10 *Artemia salina* (*A. salina*) naupilis. In each well 10 naupilis was introduced by mixed with sea water and SnO_2 NPs to attain final quantity of 5 mL in each well. After introducing of 10 naupilis to each well place it was placed for incubation at room temperature under dark conditions for 24 h and the experiment was triplicated. The LC 50 value and percentage natality were calculated from the experimental data. [20] The percentage of natality of *A. salina* was calculated by given formulae,

$$\%\ NT = (A_N / P_T) \times 100$$

Whereas;

%NT = % of Natality

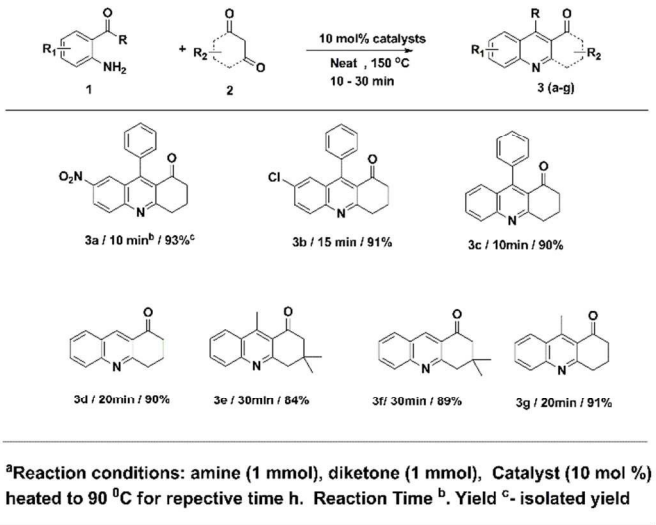
A_N = Number of alive *A. naupili*

P_T = Total number of population

SnO_2 NPs in organic synthesis

General procedure for the synthesis of 3,4-dihydroacridin-1(2H)-ones

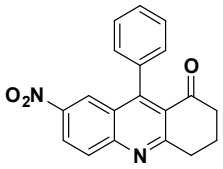
A mixture of amine, **1** (3 mmol), diketone, **2** (3 mmol) and SnO_2 NPs (10 mole %) were taken and the reaction mixture was heated at 150 °C for 15 min. The reaction progress was monitored by TLC and on completion of the reaction, the mixture was cooled to room temperature and further ethyl acetate was added to the reaction mixture. Then the reaction mixtures were centrifuged at 4000 rpm for 15 min the organic layer was then removed and it was evaporated. The residue was washed with hexane to afford the product as solid (Scheme 1). By using this methodology we have synthesized seven derivatives named as **3(a-g)** which was well characterized by spectroscopic techniques.



[a]Reaction conditions: amine (1 mmol), diketone (1 mmol), Catalyst (10 mol %) heated to 90 [0]C for repective time h. Reaction Time [b]. Yield [c]- isolated yield

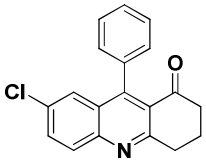
Scheme 1: Synthesis of 3,4-dihydroacridin-1(2H)-ones, **3**

Characterization of compound of 3(a-g):



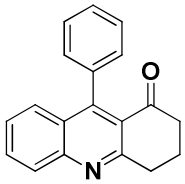
7-nitro-9-phenyl-3,4-dihydroacridin-1(2H)-one (3a)

Brown solid; Yield 93 %; mp: 195-197 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54-8.51 (m, 1H), 8.45 (d, *J*=2.4 Hz, 1H), 8.21 (d, *J*=9.2 Hz, 1H), 7.59-7.57 (m, 3H), 7.22-7.19 (m, 2H), 3.45 (t, *J*=6.4 Hz, 2H), 2.77 (t, *J*=6.4 Hz, 2H), 2.34-2.28 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.0, 34.8, 40.4, 124.9, 125.0, 125.3, 126.8, 128.0, 128.5, 130.4, 135.7, 145.5, 150.3, 153, 166.1, 197.0. LCMS: m/z calcd. for $C_{19}H_{14}N_2O_3$ 318.3 found 319.1 [M+1].



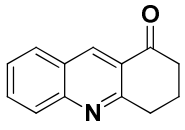
7-chloro-9-phenyl-3,4-dihydroacridin-1(2H)-one (3b)

Brown solid; Yield 91 %; mp: 183-185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J*=9.2 Hz, 1H), 7.70-7.68 (m, 1H), 7.52-7.50 (m, 3H), 7.41 (d, *J*=1.6 Hz, 1H), 7.17-7.15 (m, 2H), 3.36 (t, *J*=6.4 Hz, 2H), 2.71 (t, *J*=6.4 Hz, 2H), 2.28-2.22 (m, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.2, 34.5, 40.6, 124.4, 126.7, 127.9, 128.0, 128.3, 128.4, 130.1, 132.4, 132.6, 136.8, 147.0, 150.5, 162.5, 197.7.



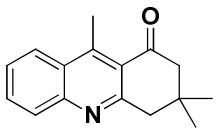
9-phenyl-3,4-dihydroacridin-1(2H)-one (3c)

Off-White solid; Yield 90 %; mp: 157-159 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J*=8.4 Hz, 1H), 7.81 (t, J=7.2 Hz, 1H), 7.58-7.38 (m, 5H), 7.22 – 7.19 (m, 2H), 3.42 (t, *J*=6.4 Hz, 2H), 2.73 (t, *J*=6.8 Hz, 2H), 2.31-2.25 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.3, 34.4, 40.6, 123.9, 126.5, 127.5, 127.6, 128.0, 128.1, 128, 128.3, 131.8, 137.5, 148.4, 151.7, 162.2, 197.8.



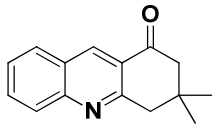
3,4-dihydroacridin-1(2H)-one (3d)

Off-White solid; Yield 90 %; mp: 109-111 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 (s, 1H), 7.97-7.95 (m, 1H), 7.84 (d, *J*=8.0 Hz, 1H), 7.74-7.70 (m, 1H), 7.48-7.44 (m, 1H), 3.23 (t, *J*=6.0 Hz, 2H), 2.71 (t, *J*=6.4 Hz, 2H), 2.22-2.16 (m, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.7, 33.4, 39.0, 126.3, 126.6, 126.8, 128.5, 129.7, 132.3, 137.0, 149.6, 161.9, 197.8.



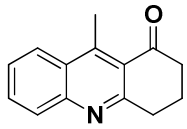
3,3,9-trimethyl-3,4-dihydroacridin-1(2H)-one (3e)

Off-White solid; Yield 84 %; mp: 108-110 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.58 (d, *J*=8.0 Hz, 1H), 8.32 (d, *J*=8.4 Hz, 1H), 7.93 (t, *J*=7.6 Hz, 1H), 7.73 (t, *J*=8.0 Hz, 1H), 3.50 (s, 2H), 3.18 (s, 3H), 2.70 (s, 2H), 1.16 (s, 6H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.8, 28.1, 32.3, 45.0, 54.4, 124.2, 125.4, 125.9, 127.8, 128.3, 134.0, 159.8, 198.2.



3,3-dimethyl-3,4-dihydroacridin-1(2H)-one (3f)

Off-White solid; Yield 89 %; mp: 101-102 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.83 (s, 1H), 8.05 (d, *J*=8.4 Hz, 1H), 7.94 (d, *J*=8.0 Hz, 1H), 7.80 (t, *J*=7.6 Hz, 1H), 7.55 (t, *J*=7.6 Hz, 1H), 3.20 (s, 2H), 2.65 (s, 2H), 1.15 (s, 6H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 28.3, 32.7, 47.2, 52.5, 125.3, 126.7, 126.8, 128.6, 129.7, 132.2, 136.5, 150.0, 160.8, 197.9.



9-methyl-3,4-dihydroacridin-1(2H)-one (3g)

Off-White solid; Yield 91 %; mp: 68-70 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J*=8.4 Hz, 1H), 8.00 (d, *J*=8.4 Hz, 1H), 7.76 (t, *J*=7.6 Hz, 1H), 7.55 (t, *J*=8.0 Hz, 1H), 3.26 (t, *J*=6.4 Hz, 2H), 3.03 (s, 3H), 2.80 (t, *J*=6.8 Hz, 2H), 2.22-2.18 (m, 2H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.0, 21.3, 34.7, 41.0, 125.3, 125.4, 126.3, 127.6, 129.1, 131.5, 147.9, 149.9, 162.1, 200.6.

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Notes and references

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† Electronic Supplementary Information (ESI) available.

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