

## Synthesis and Application of Double Perovskite $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$ as Heterogeneous and Recyclable Nanocatalyst for Quinoline Synthesis

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An efficient and economical protocol for the synthesis of substituted quinolines from various 2-amino aryl ketones and aliphatic ketones in presence of a catalytic quantity of double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  catalyst, water at ambient temperature to generate the respective quinolines in good yields. The accompanied catalyst had high activity and stability and it might be utilized at least a few times without losing its effectiveness.

**Keywords:** Double perovskite, Heterogeneous catalysis, Aryl ketones, Quinolines.

### INTRODUCTION

Quinoline is amongst the most prominent heterocyclic molecules found mostly in natural and man-made substances [1-4]. Quinoline is the most organic and conventional substances have quinoline derivatives, which seem to be attractive N-containing heterocycles within domains of pharma [5] and chemical science involved in advanced manufacturing industries [6] and these scaffolds heterocycles within disciplines of medicinal sciences [5] and chemical science involved in advanced manufacturing industries [7] forming the scaffold for substances of significant relevance had also piqued involvement in synthetic chemistry and medical sciences. Anti-inflammatory [8], antimicrobial [9], cytotoxic, anti-HIV [10] and potential anticancer effects are among the biological properties [11]. Fig. 1 depicts some of the most popular medications featuring the quinoline moiety. Quinolines also were employed extensively there in the creation of nanostructures incorporating organic light-emitting diodes.

Numerous scientific researchers have designed a variety of techniques by using a variety of catalysts Cu/Pd [12], ruthenium [13], gold [14], Brønsted acids [15], transition metals [12,16], Lewis acids [17,18], proline [19], molecular iodine [20] and ionic liquids [21,22] in different configurations due to its broad area of application domains of quinoline diversity analogs. Friedlander annulations, which incorporate a conden-

sation and cyclization reaction among a ketone bearing an active methylene group and an aromatic 2-amino aldehyde or ketone, is indeed one of the finest protocols for such production of quinoline. Nevertheless, several of these techniques struggled from expensive catalysts, relatively high temperatures, longer reaction times, low yields, and a time-consuming method to isolate the product [23,24]. In this work, synthesis of quinoline employing double perovskite  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  derivatives as recyclable and reusable catalyst as a result of intensive investigation in creating synthetic different techniques for such creation of heterocycles. Within the scientific literature, catalyst double perovskite  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  derivatives have been used to catalyze a variety of organic conversions.

### EXPERIMENTAL

Melting points were measured using Buchi R-535 equipment and are not corrected. A Bruker Advance 300 or Advance 400 spectrometer was used to record NMR spectra. For  $\text{CDCl}_3$ , chemical shifts ( $\delta$ ) are given in parts per million (ppm) using internal references or TMS as an external reference. On a Finnigan MAT 1020 mass spectrometer operating at 70 eV, mass spectra were collected.

**Preparation of double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  catalyst:** The semi-sol-gel process was used to prepare  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  phosphors with various  $\text{Eu}^{3+}$  doping concentrations.

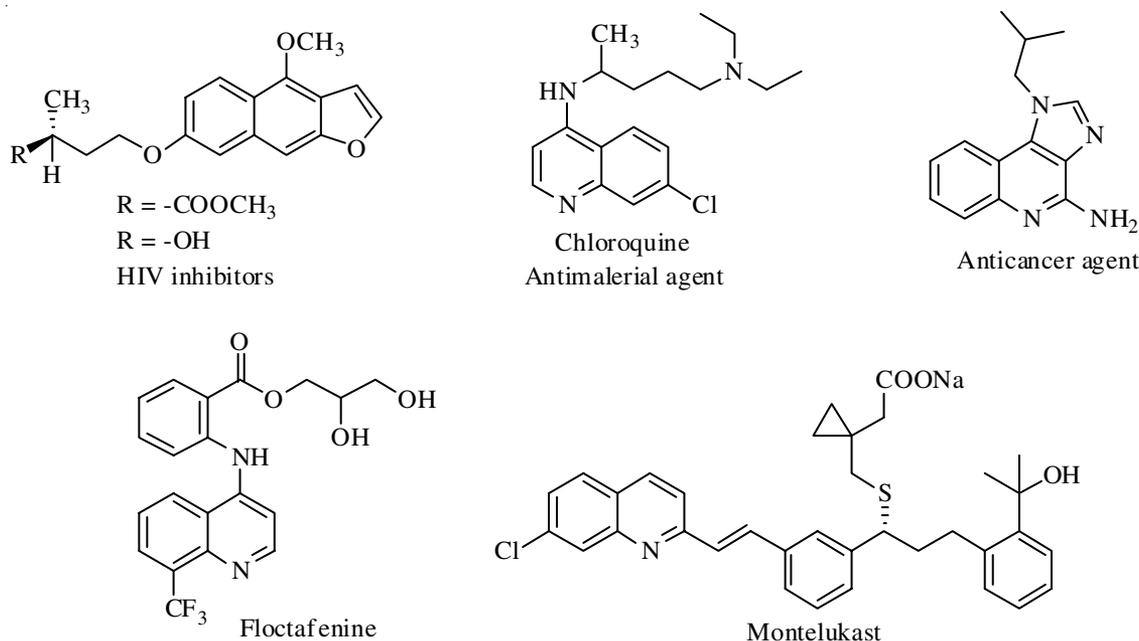
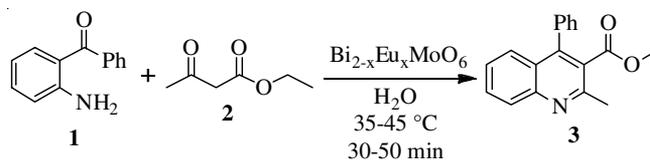


Fig. 1. Biologically active quinoline derivatives

$Bi_2O_3$ ,  $Eu_2O_3$  (99.99%),  $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ ,  $HNO_3$  and citric acid were the starting components, and used without additional refinement. The method for preparing  $BiEuMoO_6$  samples is as follows: in weak nitric acid, 3.5360 g  $Bi_2O_3$  and 0.26416 g  $Eu_2O_3$  was dissolved. Following the complete dissolution of the  $Bi_2O_3$  and  $Eu_2O_3$ , a little quantity of citric acid was added to the aforesaid solution, resulting in a molar ratio of total chelated metal cations to citric acid of 1:1.5. Then, in a separate beaker, 1.47229 g of  $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$  (AR) was dissolved in an appropriate amount of deionized water, and liquor ammonia was added to avoid the generation of the precipitate. Afterward, with magnetic stirring, the prepared  $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$  (AR) solution was slowly added to the reaction mixture that included  $Bi^{3+}$  and  $Eu^{3+}$  and the pH of the mixed solution was near to 7.0 by adding  $NH_4OH$  solution dropwise. It produced a clear solution at lower pH values, however when the pH was maintained at  $\sim 7.0$ , it precipitated slightly. The obtained product was therefore heated at  $80^\circ C$  for a period of time till the quantity was reduced to half, resulting in a semi-sol with certain precipitation. The sol was heated subsequently (at  $120-150^\circ C$ ) with a gelating reagent, ethylene glycol, to generate a gel that ignites and yields a black powder. To create a grey precursor, the powder could be further dried on an electric burner at  $300^\circ C$  for 20-30 min. To produce the desired phosphor sample, the precursor was annealed in a muffle furnace for 5 h at 500, 600 and  $700^\circ C$ .

**General reaction:** Double perovskite  $Bi_{1.97}Eu_{0.03}MoO_6$  (0.033 g, 1 mol%) was added to a combination of 2-amino aryl ketones **1a** (1.0 mmol) and aliphatic ketones **2a** (1.0 mmol) in water (5 mL), and the mixture was agitated at  $45-55^\circ C$  for 35 min. Thin-layer chromatography (TLC) was used to monitor the reaction until the starting material was completely gone. After the reaction was completed, the catalyst was filtered and washed with water before being utilized in the next step

**(Scheme-I).** The mixture was then evacuated using a rotary evaporator, and the solid product was purified using column chromatography.



Scheme-I: Synthesis of quinolines

**Ethyl 2,4-dimethylquinoline-3-carboxylate (3a):** Colour: yellow solid; m.p.:  $269-273^\circ C$ . IR (KBr,  $cm^{-1}$ ): 3070, 2830, 1726, 1624, 1594, 1217, 1085, 590.  $^1H$ NMR (300 MHz,  $CHCl_3-d_6$ ) ( $\delta$  ppm): 1.50 (t, 3H,  $J = 7.2$  Hz), 2.65 (s, 3H), 2.60 (s, 3H), 4.40 (q, 2H,  $J = 7.2$  Hz), 7.60 (t, 1H,  $J = 7.2$  Hz), 7.70 (t, 1H,  $J = 7.2$  Hz), 7.97 (d, 1H,  $J = 8.4$  Hz), 8.0 (d, 1H,  $J = 8.5$  Hz).  $^{13}C$ NMR (75 MHz,  $CHCl_3-d_6$ ) ( $\delta$  ppm): 14.14, 15.50, 23.44, 61.44, 123.92, 125.83, 126.14, 127.96, 129.25, 129.90, 141.30, 147.4, 154.26, 168.91. EIMS  $m/z$ : 229, 215, 201, 184, 155, 129, 116, 88, 79.

**Ethyl 2-methyl-4-phenylquinoline-3-carboxylate (3b):** Colour: white solid; m.p.:  $99-101^\circ C$ . IR (KBr,  $cm^{-1}$ ): 3035, 2962, 1700, 1610, 1570, 1488, 910.  $^1H$  NMR (300 MHz,  $CHCl_3-d_6$ ) ( $\delta$  ppm): 1.32 (t, 3H,  $J = 7.0$  Hz), 2.83 (s, 3H), 4.24 (q, 2H,  $J = 7.0$  Hz), 7.30-7.59 (m, 6H), 7.79 (d, 1H,  $J = 8.1$  Hz), 7.82 (t, 1H,  $J = 7.9$  Hz), 8.13 (d, 1H,  $J = 8.1$  Hz).  $^{13}C$  NMR (75 MHz,  $CHCl_3-d_6$ ) ( $\delta$  ppm): 13.70, 23.33, 68.91, 96.22, 125.3, 126.3, 126.5, 127.4, 128.3, 129, 129.6, 135.6, 135.5, 145.8, 147.6, 153.2, 166.7. MS  $m/z$ : 291 (M+1), 281, 264, 246, 221, 207, 191, 148, 133, 73.

**9-Methyl-1,2,3,4-tetrahydroacridine (3c):** Colour: white solid; m.p.:  $76-79^\circ C$ . IR (KBr,  $cm^{-1}$ ): 2929, 1570, 1477, 1349, 1165, 1074, 940, 840, 820, 797, 754, 710.  $^1H$ NMR (300 MHz,

$\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 1.57-1.67 (m, 4H), 2.57 (s, 3H), 2.92 (t, 2H,  $J = 7.5$  Hz), 3.12 (t, 2H,  $J = 7.6$  Hz), 7.41-7.97 (m, 4H).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 12.93, 22.38, 22.73, 26.44, 33.89, 122.85, 124.55, 126.68, 127.66, 128.45, 140.82, 145.54, 161.97. EIMS  $m/z$ : 199 ( $\text{M}^+$ , 87), 125 (100).

**7-Methyl-5, 6-dihydrobenzo[*c*]acridine (3d):** Colour: white solid; m.p.: 112 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3080, 3022, 2948, 2844, 1686, 1586, 1494, 1217, 758.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 2.67 (s, 3H), 3.10 (t, 2H,  $J = 7.0$  Hz), 3.17 (t, 2H,  $J = 6.8$  Hz), 7.17-8.57 (m, 8H).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 13.66, 25.10, 27.85, 123.40, 125.37, 126.34, 127, 127.53, 128.36, 128.92, 129.15, 129.98, 133.13, 134.96, 138.89, 139.52, 146.71, 152.35. MS  $m/z$ : 246 ( $\text{M}^+$ , 100), 212 (30) 125 (31).

**Ethyl 2-methyl-4-phenylquinoline-3-carboxylate (3e):** Colour: white solid; m.p.: 99-103 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3034, 2968, 1705, 1625, 1570, 1482, 910.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 1.35 (t, 3H,  $J = 7.0$  Hz), 2.83 (s, 3H), 4.25 (q, 2H,  $J = 7.0$  Hz), 7.34-7.68 (m, 6H) 7.71 (d, 1H,  $J = 8.1$  Hz), 7.83 (t, 1H,  $J = 7.9$  Hz), 8.15 (d, 1H,  $J = 8.1$  Hz).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 13.66, 23.39, 68.84, 96.12, 125.12, 126.5, 126.6, 127.5, 128.4, 129.2, 129.5, 135.9, 135.7, 145.5, 147.2, 153.3, 167.4. MS  $m/z$ : 291 ( $\text{M}^+$ ), 281, 264, 246, 221, 207, 191, 147, 133, 73.

**7-Chloro-9-phenyl-2,3-dihydro-1H-cyclopenta[*b*]quinoline (3f):** Colour: white solid; m.p.: 102-104 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3435, 3044, 2952, 1970, 1923, 1757, 1601, 1580, 1484, 1445, 1382, 1344, 1306, 1203, 1162, 1124, 1073, 1022, 952, 879, 822, 750, 707, 655.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 2.12-2.24 (m, 2H), 2.92 (t, 2H,  $J = 7.2$  Hz), 3.24 (t, 2H,  $J = 7.0$  Hz), 7.33-7.55 (m, 7H), 7.96 (d, 1H,  $J = 8.5$  Hz).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 23.30, 30.93, 35.04, 124.44, 125.28, 126.90, 128.27, 129.11, 129.89, 130.33, 131.22, 138.01, 141.84, 144.92, 162.80. MS  $m/z$ : 279 ( $\text{M}^+$ ), 280, 276, 246, 230, 203, 190, 179, 158, 150, 128.

**1-(6-Chloro-2-methyl-4-phenylquinolin-3-yl)ethanone (3g):** Colour: white solid; m.p.: 147-151 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3028, 2962, 1704, 1602, 1562, 1483, 907, 605.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 1.98 (s, 3H), 2.64 (s, 3H), 7.32-7.22 (m, 7H), 8.03 (d, 1H,  $J = 8.9$  Hz).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 23.55, 31.65, 124.73, 125.84, 128.88, 129.21, 129.83, 130.82, 132.29, 134.50, 135.56, 142.96, 145.96, 153.88; MS  $m/z$ : 295 ( $\text{M}^+$ ), 280, 254, 154, 136, 91, 81, 69, 55.

**Isopropyl-6-chloro-2-methyl-4-phenylquinoline-3-carboxylate (3h):** Colour: white solid; m.p.: 124-125 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3428, 3060, 2991, 2929, 1902, 1720, 1600, 1574, 1561, 1480, 1450, 1391, 1310, 1226, 1184, 1100, 1083, 955, 902, 872, 830, 814, 761, 703.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 0.89 (d, 6H,  $J = 6.1$  Hz), 2.72 (s, 3H), 4.82 (heptet, 1H,  $J = 6.1$  Hz), 7.32 (d, 2H,  $J = 7.65$  Hz), 7.38 (t, 4H,  $J = 7.65$  Hz), 7.50 (dd, 1H,  $J = 9.0$  & 2.2 Hz), 7.88 (d, 1H,  $J = 8.4$  Hz). MS  $m/z$ : 340 ( $\text{M}^+$ ), 292 (100), 264 (16).

**7-Chloro-3,3-dimethyl-9-phenyl-3,4-dihydroacridine-1(2H)-one (3i):** Colour: yellow solid; m.p.: 220-224 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3074, 2954, 2858, 1690, 1551, 1482, 1380, 1293, 1193, 1081, 834, 694.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 1.11 (s, 6H), 2.54 (s, 2H), 3.27 (s, 2H), 7.12 (t, 2H), 7.30 (s,

1H), 7.50-7.55 (t, 3H) 7.61-7.65 (dd, 1H), 7.98-8 (d, 1H,  $J = 9.06$  Hz).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 24.2, 27.3, 45.2, 55.4, 127.2, 127.8, 128.2, 129.1, 129.9, 131.2, 132.6, 133.5, 139.3, 146.2, 148.4, 158.7, 197.4; MS  $m/z$ : 336, 280, 250, 245, 217, 249, 131, 113.

**2-tert-Butyl-7-chloro-9-phenyl-1,2,3,4-tetrahydroacridine (3j):** Colour: white solid, m.p.: 154-157 °C. IR (KBr,  $\text{cm}^{-1}$ ): 3042, 2991, 2893, 1600, 1564, 1474, 1368, 1353, 1162, 1072, 952, 824, 762, 702.  $^1\text{H}$  NMR (300 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 0.88 (s, 9H), 1.43-1.64 (m, 2H), 2.22-2.32 (m, 2H), 2.62-2.69 (m, 1H), 3.03-3.10 (m, 1H), 3.24-3.33 (m, 1H), 7.16-7.23 (m, 3H), 7.52-7.60 (m, 4H), 7.92 (s, 1H).  $^{13}\text{C}$  NMR (125 MHz,  $\text{CHCl}_3-d_6$ ) ( $\delta$  ppm): 23.97, 27.3, 29.2, 32.5, 34.7, 44.5, 124.5, 127.2, 128.7, 129.2, 129.6, 129.4, 130.2, 131.1, 136.3, 144.6, 145.9, 159.7. MS  $m/z$ : 350 ( $\text{M}^+$ ), 349, 293, 292, 57.

## RESULTS AND DISCUSSION

**Crystallinity and phase purity:** The orthorhombic (L)- $\text{Bi}_2\text{MoO}_6$  category crystal was annealed at 700 °C for 5 h, which exhibit a remarkable phase purity and high crystallinity (JCPDS No. 21-0102). Zhang *et al.* [17] encountered a similar XRD pattern for such identical specimen generated by hydrothermal technique and annealed at 500 °C for 2 h. There were no additional impurity phases in the XRD pattern and the peak positions corresponded nicely. The powder XRD patterns show that when the concentration of dopant  $\text{Eu}^{3+}$  increases, the crystal structure remains unchanged, but the position of the major peak shifts somewhat, indicating fair  $\text{Eu}^{3+}$  integration within the host lattice (Fig. 2).

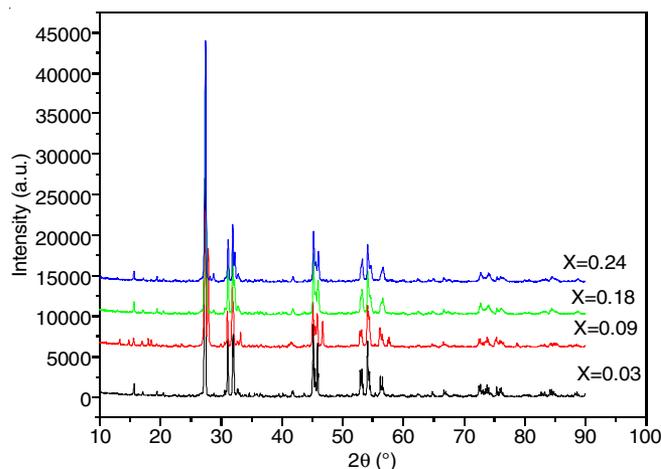


Fig. 2. XRD pattern for  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6:\text{Eu}^{3+}$  ( $x = 0.0-0.24$ ) with different  $\text{Eu}^{3+}$  concentrations

**SEM and EDAX analysis:** The SEM image and EDAX profile of a representative sample of  $x = 0.09$  can be seen in Fig. 3. Powdered particles in the compound have a roughly spherical form having diameters ranging from 40 to 120 nm, along with larger micron-sized particles with aggregation in certain places. The particle morphologies seem to be nearly the same as with different  $\text{Eu}^{3+}$  concentrations in the series.  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  samples generated through hydrothermal technique yielded 2D nanostructures such as nanoplates or nano-

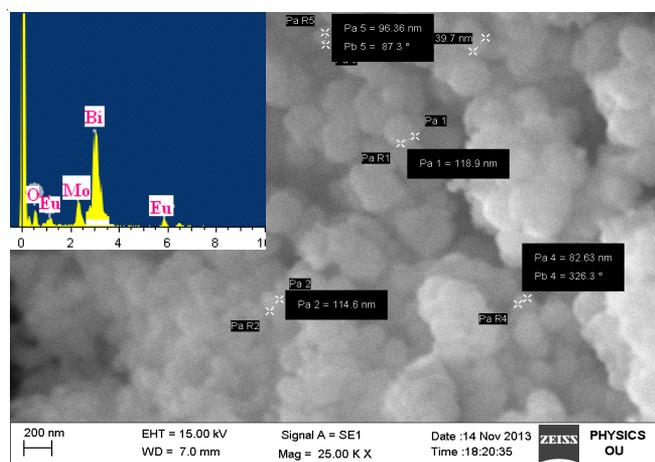


Fig. 3. SEM & EDAX image showing morphology and composition of  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$

flakes. A sol-gel approach of fabrication including an acidic precursor solution (pH = 1-2) resulted in aberrant forms ranging in size from 200 nm to 1 micron. The particle sizes of conventional phosphor specimens in the industry are typically in the range of 2-10 nm. Since the prepared particles are also nano and micron in size, thus their emission intensities are identical to those of conventional red phosphors. As a result, the double perovskite powders generated can be used in luminescence, touch panels and WLEDs.

The EDAX profile of  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  ( $x = 0.09$ ) is shown in the inset of Fig. 3. The occurrence including all components as determined by the specimen can be seen in the spectra and the determined stoichiometric correlations of elements were noticed to be similar to the intended stoichiometry of such specimen.

**Chemistry:** In order to optimize the reaction conditions, (2-aminophenyl)(phenyl)methanone (**1a**) and ethyl 3-oxobutanoate (**2a**) were used as model substrates and a few experimental studies to synthesize the quinoline **3a** (Table-1). The starting material (2-aminophenyl)(phenyl)methanone (**1a**) (1.0 mmol) were allowed to dissolve in ethyl 3-oxobutanoate (**2a**) (1.0 mmol) for 30 to 50 min at 35-45 °C for the synthesis of quinoline **3a** using a double perovskite  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  as

catalyst. Optimum amount of double perovskite  $\text{Bi}_{2-x}\text{Eu}_x\text{MoO}_6$  were used for the synthesis of quinolone and its derivatives. Also the reaction conditions with different ratios of bismuth and europium were also optimized. In addition, the reusability efficiency of the catalyst for same reaction was also conducted.

TABLE-1  
OPTIMIZATION OF THE REACTION CONDITIONS

Catalyst	Solvent	Time (min)	Yield (%)
$\text{Bi}_2\text{MoO}_6$	$\text{H}_2\text{O}$	60	21
$\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$	$\text{H}_2\text{O}$	50	98
$\text{Bi}_{1.94}\text{Eu}_{0.06}\text{MoO}_6$	$\text{H}_2\text{O}$	40	52
$\text{Bi}_{1.91}\text{Eu}_{0.09}\text{MoO}_6$	$\text{H}_2\text{O}$	50	39
$\text{Bi}_{1.88}\text{Eu}_{0.12}\text{MoO}_6$	$\text{H}_2\text{O}$	65	24
$\text{Bi}_{1.85}\text{Eu}_{0.15}\text{MoO}_6$	$\text{H}_2\text{O}$	60	11
$\text{Bi}_{1.82}\text{Eu}_{0.18}\text{MoO}_6$	$\text{H}_2\text{O}$	70	18
$\text{Bi}_{1.79}\text{Eu}_{0.21}\text{MoO}_6$	$\text{H}_2\text{O}$	80	29
$\text{Bi}_{1.76}\text{Eu}_{0.24}\text{MoO}_6$	$\text{H}_2\text{O}$	85	35

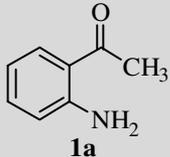
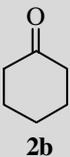
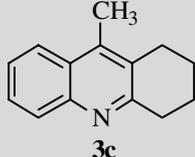
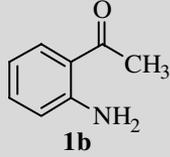
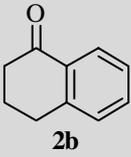
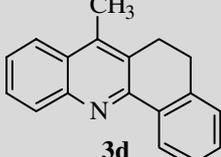
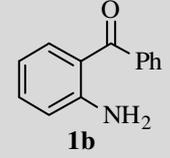
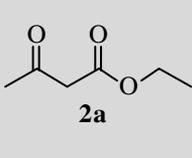
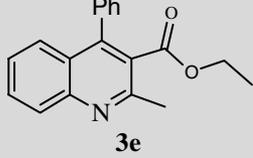
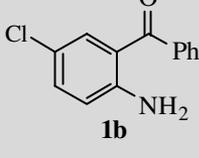
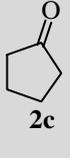
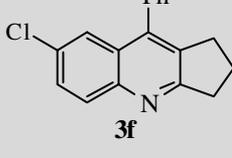
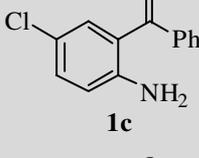
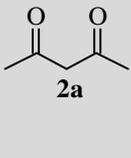
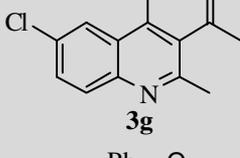
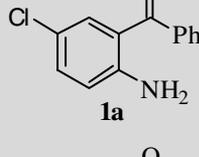
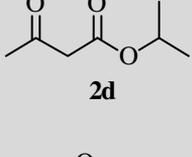
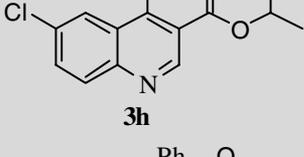
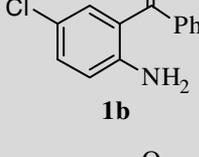
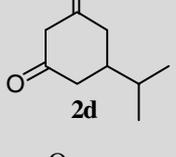
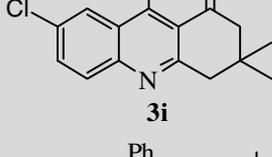
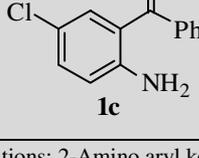
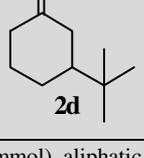
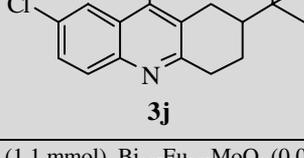
During the course of the experimental work, no product was formed in presence of pure Mo(IV) oxide and Mo(VI) oxide. Among various conditions of catalyst, double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  (1 mol%) catalyst is considered as the best ratio (Bi:Eu) to give the maximum yield within 35 min at 40 °C in water.

The optimized conditions were applied in the reactions of 2-amino aryl ketones **1a-c** with other aliphatic ketones **2a-d** with various substitution methods in order to broaden the scope of the reaction and the results are summarized in Table-2. Present method is applicable to a wide range of substituted 2-amino aryl ketones including electron-withdrawing groups, as shown in Table-2 (Entries 1-5), yielding excellent yields to desired products in all cases. Furthermore, the potential outcome of combining 2-amino aryl ketones **1a-e** with aliphatic ketones (**2b**) was also examined (Table-2, entries 6-10). Using such substrates and the double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  under optimum reaction circumstances, a variety of substituted quinolines was produced in excellent yields.

2-Amino aryl ketones reacted with aliphatic ketones in 10 mL of 1,2-dichloroethane under comparable optimal conditions using a double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  catalyst (0.05 mol%) at 45-55 °C in 10 mL of water. Over six trials

TABLE-2  
DOUBLE PEROVSKITE  $\text{BiEuMoO}_6$  PROMOTED SYNTHESIS OF QUINOLINES  
FROM 2-AMINO AROMATIC CARBONYL COMPOUNDS

Entry	2-Amino aryl ketones (1)	Aliphatic ketones (2)	Product (3)	Time (min)	Isolated yield (%)
1				45	90
2				40	92

3	 <b>1a</b>	 <b>2b</b>	 <b>3c</b>	50	94
4	 <b>1b</b>	 <b>2b</b>	 <b>3d</b>	45	98
5	 <b>1b</b>	 <b>2a</b>	 <b>3e</b>	45	87
6	 <b>1b</b>	 <b>2c</b>	 <b>3f</b>	35	92
7	 <b>1c</b>	 <b>2a</b>	 <b>3g</b>	45	89
8	 <b>1a</b>	 <b>2d</b>	 <b>3h</b>	40	92
9	 <b>1b</b>	 <b>2d</b>	 <b>3i</b>	45	94
10	 <b>1c</b>	 <b>2d</b>	 <b>3j</b>	50	97

Reaction conditions: 2-Amino aryl ketones (1.0 mmol), aliphatic ketones (1.1 mmol),  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  (0.05 mol),  $\text{H}_2\text{O}$  (3 mL).

under similar circumstances as in the first, the catalyst demonstrated good recoverability and reusability. Under the optimized (up to 6 runs), double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  catalyst was shown to be highly stable and reusable with no appreciable loss of catalytic activity (Table-3).

#### CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

TABLE-3  
REUSES OF THE DOUBLE PEROVSKITE  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$   
CATALYST IN THE REACTION OF 2-AMINO ARYL  
KETONES REACT WITH ALIPHATIC KETONE (2a)

Run No. <sup>a</sup>	1	2	3	4	5	6
Yield (%) <sup>b</sup>	98	92	90	85	80	70

<sup>a</sup>Reaction conditions: 2-Amino aryl ketones (5.0 mmol) and aliphatic ketones (5.0 mmol), double perovskite  $\text{Bi}_{1.97}\text{Eu}_{0.03}\text{MoO}_6$  (0.05 mmol, 0.165 g) in water (10 mL) at room temperature for 35 min. <sup>b</sup>Isolated yields.

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