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MICROWAVE-INDUCED BISMUTH TRIIODIDE-CATALYZED FACILE SYNTHESIS OF OCTAHYDROXANTHENES

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Abstract:

Microwave-induced reaction of 1,3-cyclohexanedione with numerous aldehydes using bismuth iodide is performed successfully toward the synthesis of important octahydroxanthenes. A most probable mechanism is suggested to explain the formation of products.

Key Words:

Microwave, Bismuth Iodide, Mechanism, Octahydroxanthenes

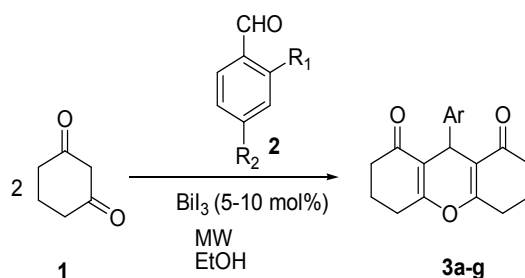
Introduction:

Benzoxanthenes are privileged chemotypes present in numerous medicinally active substrates. Xanthenedione system is found in many natural compounds and dyes. Due to their importance, a several synthetic methods have been developed for the preparation of xanthenes and their functionalized analogues. For examples, xanthenes were synthesized by condensation of activated methylene compounds with aldehydes in the presence of mineral acids [1], ring-closure reaction of polycyclic aromatic triflate ester derivatives [2], reaction of Grignard reagent with triethylorthoformate [3], selective *O*-alkylation reaction of monopodal xanthenes [4], reaction with nano-WO₃-supported sulfonic acid [5], reaction with Amberlite IR-120H [6], and reaction with proline-triflate in water [7]. Some of these methods are designated as good methods although minor or major limitations are seen in all of them. Drawbacks of these reported methods include use of toxic organic solvents and costly reagents or catalysts combinations and with low yields of the products. In continuation of our research on bismuth salts-catalyzed reactions for the efficient synthesis of diverse organic compounds, we report herein an expeditious method for the preparation of various xanthenes using catalytic amounts of non-toxic bismuth iodide under microwave-induced conditions [8-9].

Results and Discussions:

Microwave-induced reactions have received significant attention from scientists. This method has accelerated reaction rates significantly of many chemical reactions. Some reactions which were difficult to perform under conventional methods are made possible with microwave. Our research group has been engaged in bismuth salts-induced and microwave-induced chemical processes for many years [8-9]. Our studies in these areas have culminated in the synthesis of a variety of organic molecules. During this study, we realize octahydroxanthenes can be easily prepared following our protocol.

Reaction of 1,3-cyclohexanedione with various aromatic aldehydes in the presence of several

SCHEME1**TABLE 1:** Bismuth Iodide catalyzed Microwave-Induced synthesis of 9-aryl-1,8-dioxo-octahydroxanthenes

Entry	R ¹	R ²	Time (min)	Compound(s)	Yield(s) ^a (%)
1	H	H	2	3a	90
2	CH ₃	H	5	3b	85
3	H	CH ₃	4	3c	92
4	OCH ₃	H	3	3d	87
5	H	OCH ₃	4	3e	95
6	H	Cl	5	3f	85
7	Cl	H	6	3g	80

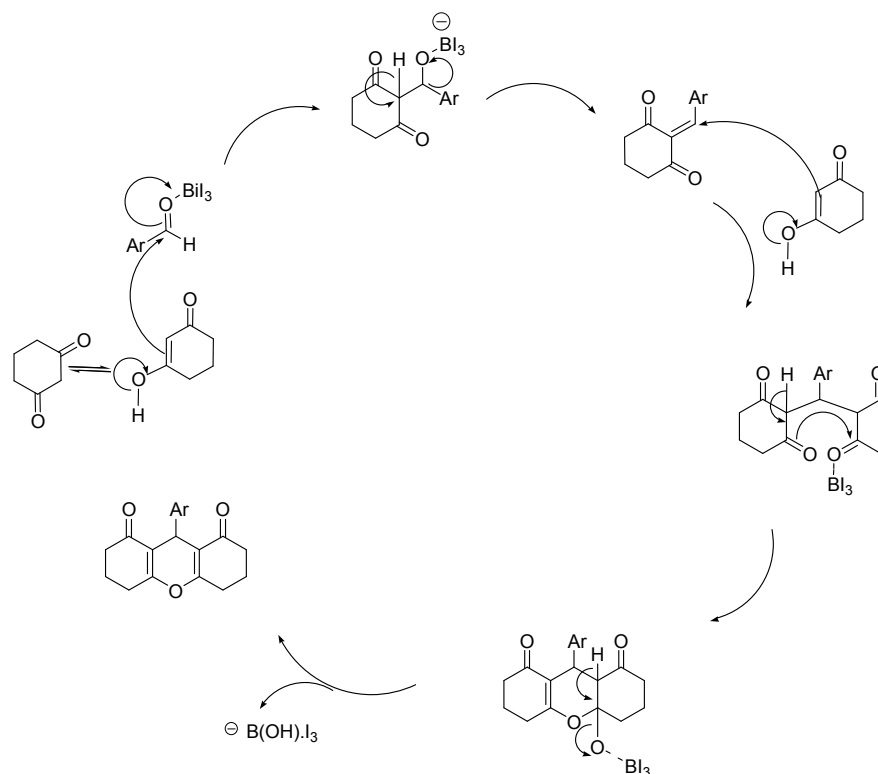
a : Isolated yield after short column pad purification followed by crystallization. Ar: 2,4-disubstituted benzaldehyde(2)

bismuth (III) salts as a catalyst was conducted. For example, bismuth nitrate pentahydrate, bismuth chloride, bismuth bromide, bismuth iodide, bismuth oxide and bismuth subnitrate was used to identify the best catalyst system in this reaction. Bismuth iodide in ethanol was proved to be the best catalyst for this goal. Microwave-induced reactions accelerated the process significantly and the reaction was completed within 6-7 min at medium power and 60⁰C temperature. The yield of the product was found to be approximately 70-75%. The tested substrates indicate substituents in the aromatic ring has no effects on this reaction [Scheme 1, Table 1].

The mechanistic route of this reaction is not investigated in detail. However, the formation of octahydroxanthenes is explained considering the nature of the substrates and catalyst. The cyclohexane diketone exists in its enol form in the presence of acidic bismuth iodide and undergoes reaction with aromatic aldehydes to create ortho-quinonemethide intermediate. Enolization is highly possible through a coordination of the electronegative oxygen with the empty d-orbital of bismuth atom. This intermediate is well-suited to follow a Michael-type of condensation with highly reactive diketone. A facile dehydration takes place and this produces the cyclic product. Clearly the formation of the enol, coordination of the oxygen

with the vacant d-orbital of bismuth and dehydration are facilitated by microwave irradiation due to high energy release

[Scheme 2].



SCHEME 2: Proposed mechanism for Bismuth iodide-catalyzed microwave-assisted synthesis of 9-aryl-1,8-dioxo-octahydroxanthene

Experimental:

To a mixture of the diketone (2 mmol) and aldehyde (1 mmol) was added bismuth iodide (10 mol%) in ethanol (1 mL). The reaction mixture was irradiated in a CEM microwave oven at 60⁰C at power 300 watts for 6 min. After the reaction, dichloromethane (10 mL) and water (2 mL) was added to the reaction mixture, organic layer was collected and dried with sodium sulfate. The crude product was isolated after evaporation of the solvent which was purified by a short column of silica gel using ethylacetate and hexanes as the solvent (20: 80). The products obtained from this study have shown identical physicochemical data as reported [1-2, 4-7].

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References:

- [1] Hilderbrand, S.A.; Weissleder, R. One-pot Synthesis of New Symmetric and Asymmetric Xanthene Dyes, *Tetrahedron Lett.*, **2007**, *48*, 4383–4385.
- [2] Wang, J.-Q.; Harvey, R.G. Synthesis of Polycyclic Xanthenes and Furans via Palladium-Catalyzed Cyclization of Polycyclic Aryltriflate Esters, *Tetrahedron*, **2002**, *58*, 5927–5931.
- [3] Casiraghi, G.; Casnati, G.; Cornia, M. Regiospecific Reactions of Phenol Salts. Reaction-Paths of Alkylphenoxymagnesium Halides with Triethyl Orthoformate, *Tetrahedron Lett.*, **1973**, *9*, 679–682.
- [4] Iniyavan, P.; Sarveswari, S.; Vijayakumar, V. Synthesis and Antioxidant Studies of Novel Bi-, Tri-, and Tetrapodal 9-aryl-1,8-dioxo-octahydroxanthenes, *Tetrahedron Lett.*, **2015**, *56*, 1401-1406.
- [5] Amoozadeh, A.; Rahmani, S. Nano-WO₃-supported Sulfonic Acid: New, Efficient and High Reusable Heterogeneous Nano Catalyst, *J. Mol. Catal. A: Chem.*, **2015**, *396*, 96-107.
- [6] Nisar, M.; Ali, I.; Raza Shah, M.; Badshah, A.; Qayum, M.; Khan, H.; Khan, I.; Ali, S. Amberlite IR-120H as a Recyclable Catalyst for the Synthesis of 1,8-Dioxo-octahydroxanthenes Analogs and Their Evaluation as Potential Leishmanicidal Agents, *RSC Adv.*, **2013**, *3*, 21753-21758.
- [7] Li, J.; Lu, L.; Su, W. A New Strategy for the Synthesis of Benzoxanthenes Catalyzed by Proline Triflate in Water, *Tetrahedron Lett.*, **2010**, *51*, 2434–2437.
- [8] We have been engaged in microwave-induced reactions. For examples of microwave-induced reactions from our laboratory, see: (a) Banik, B. K.; Barakat, K. J.; Wagle, D. R.; Manhas, M. S.; Bose, A. K.; Microwave-Assisted Rapid and Simplified Hydrogenation, *J. Org. Chem.*, **1999**, *64*, 5746-5753; (b) Banik, B. K.; Aguilar, H.; Cordova, D.; Unprecedented Stereocontrol of β -Lactam Formation Derived From N-Cinnamylidene Arylamine, *Heterocycles*; **2008**, *11*, 2321-2329; (c) Kall, A.; Bandyopadhyay, D.; Banik, B. K.; Microwave-Induced Aza-Michael Reaction in Water: A Remarkable Simple Procedure, *Synthetic Communications*; **2010**, *40*, 1730-1735; (d) Ramos, K.; Banik, B. K.; Microwave-Induced Clay-Mediated Preparation of Imines: One-Pot Synthesis of β -Lactams, *Heterocyclic Letters*; **2011**, 27-30; (e) Banik, I.; Becker, F. F.; Banik, B. K.; Microwave-Induced Stereospecific Synthesis of β -Lactams Derived from Polyaromatic Imines: Influence of Multicyclic Rings at the Nitrogen, *Heterocyclic Letters*; **2011**, 55-57; (f) Bandyopadhyay, D.; Yanez, M. A.; Banik, B. K.; Microwave-Induced Stereoselectivity of β -Lactam Formation, Effects of Solvents; *Heterocyclic Letters*; **2011**, 65-67; (g) Bandyopadhyay, D.; Mukherjee, S.; Banik, B. K.; An Expedient Synthesis of N-Substituted Pyrroles by Microwave-Induced Iodine-Catalyzed Reactions Under Solventless Conditions; *Molecules*; **2010**, *15*, 2520-2525; (h) Bandyopadhyay, D.; Mukherjee, S.; Rodriguez, R.; Banik, B. K.; An Effective Microwave-Induced Iodine-Catalyzed Method for the synthesis of Quinoxalines via Condensation of 1,2-Diamines with 1,2-Dicarbonyl Compounds, *Molecules*; **2010**, *15*, 4207-4212; (i) Bandyopadhyay, D.; Cruz, J.; Banik, B. K.; Microwave-Induced Synthesis of 3-Pyrrole Substituted β -Lactams Via Bismuth Nitrate-Catalyzed Reaction, *Tetrahedron Symposium-in-Print*; **2012**, *68*, 10686-10695.
- [9] For some reactions with bismuth salts developed in our laboratory, see: (a) Rivera, S.; Bandyopadhyay, D.; Banik, B. K.; Facile Synthesis of N-Substituted Pyrroles Via Microwave-Induced Bismuth Nitrate-Catalyzed Reaction Under Solventless Conditions, *Tetrahedron Lett.*, **2009**, *50*, 5445-5448; (b) Srivastava, N.; Dasgupta, S.

K.; Banik, B. K.; A Remarkable Bismuth Nitrate-Catalyzed Protection of Carbonyl Compounds, *Tetrahedron Lett.*, **2003**, 44, 1191-1193; (c) Banik, B. K.; Cardona, M.; Bismuth Nitrate-Catalyzed Novel Synthesis of Pyrrole-Substituted Indolinones; *Tetrahedron Lett.*, **2006**, 47, 7385-7387; (d) Bose, A.; Sanjoto, P.; Villarreal, S.; H. Aguilar; Banik, B. K.; Novel Nitration of Estrone by Metal Nitrate, *Tetrahedron Lett.*, **2007**, 48, 3943-3946; (e) Bandyopadhyay, D.; Banik, B. K., Microwave-Induced Bismuth Nitrate-Catalyzed Expeditious Enamination of β -Dicarbonyl Compounds Under Solvent-free Conditions, *Heterocyclic Letters*; **2011**, 17-21; (f) Lerma, J; Banik, B. K.; Synthesis of Glucose peracetate via Bismuth Nitrate-Induced Reaction; *Heterocyclic Letters*; **2011**, 35-36; (g) Alvarez, D; Banik, B. K.; Stereospecific Synthesis of Glycosyl Chloride Using a Combination of Bismuth Nitrate and Bismuth Chloride, *Heterocyclic Letters*; **2011**, 37-39; (h) Banik, A.; Batta, S. Bandyopadhyay, D.; Banik, B. K.; A Highly Efficient Bismuth Salts-Catalyzed Route for the Synthesis of α -Aminophosphonates, *Molecules*; **2010**, 15, 8205-8213.

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