A new ring bromination method for aromatic compounds under solvent-free conditions with NBS/Al_2O_3

Gholamhassan K. Imanzadeh*, Mohammad R. Zamanloo, Habibollah Eskandari and Keyvan Shayesteh

College of Chemistry, Mohagheghe Ardebili University, Ardebil 179, I.R. Iran

---

Alumina supported *N*-bromosuccinimide was found to be an efficient reagent for ring bromination of a number of aromatic compounds under solvent-free conditions. In the absence of the alumina the reactions are slow and some of the substrates are recovered unchanged. Under the reaction conditions aromatic oximes are converted into the corresponding carbonyl compounds. The method is simple, safe and rapid.

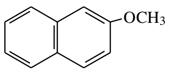
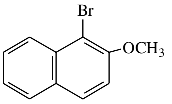
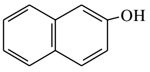
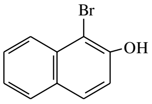
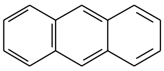
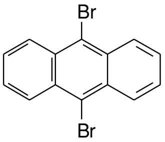
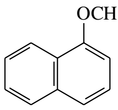
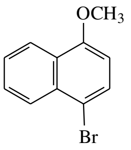
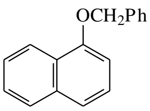
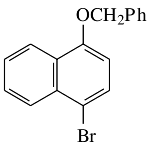
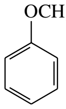
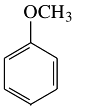
Keywords: alumina supported *N*-bromosuccinimide, aromatic ring bromination, solvent-free system

---

Brominated arenes are important and versatile intermediates for the synthesis of a wide variety of biologically active compounds.[1] The direct bromination of aromatic systems with Br_2 generates toxic and corrosive hydrogen bromide which causes serious environmental pollution. To overcome this problem various reagents have been developed, including KBr–H_2O_2,[2] KBr-$NaBrO_3.4H_2O$,[3] and BuOBr–zeolite.[4] Some of these methods suffer from harsh reaction conditions or cumbersome extraction procedures; therefore a simple and better method is desirable.

N-Bromosuccinimide (NBS) is an important, popular and inexpensive reagent for the bromination and oxidation of organic compounds.[5,6] By this reagent primary and secondary alcohols are converted into corresponding aldehydes and ketones.[7,8] NBS was also used in the oxidation of sulfides to sulfoxides in the presence of methanol as a solvent.[8] In the solution, phase, arenes have been brominated either in the side chain with NBS and free radical initiators such as light or in the aromatic ring when no radical initiator is present.[9] In continuation of our interest in the development of environmentally friendlier synthetic methods under solvent free conditions,[10-15] we have found a new and versatile reagent for ring bromination of a series of aromatic compounds in solvent-free systems. This reagent is NBS–Al_2O_3 and it is easily prepared by grinding together weighed amounts of alumina and NBS. Our investigations showed that the ring bromination reaction of the aromatic compounds was achieved by mixing finely powdered reagent with the substrate. In a few cases the reactions are completed upon simple mixing and gentle warming in a test tube reactor accelerates some others (Table 1). In the absence of the alumina the reactions are slow and some of the substrates are recovered unchanged. As an example the reaction of anthracene with NBS in the absence of alumina yields only 20% of 9,10-dibromoanthracene.

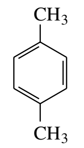
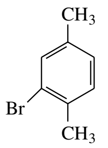
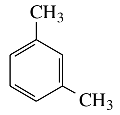
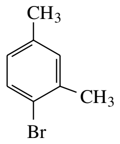
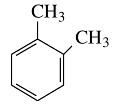
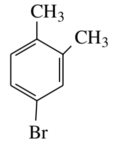
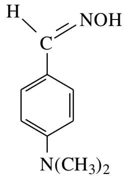
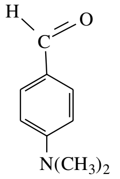
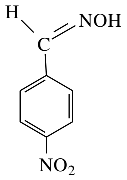
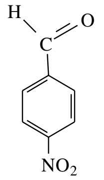
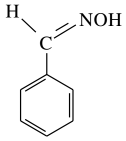
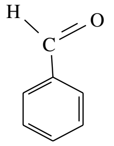
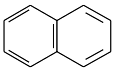
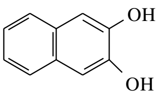
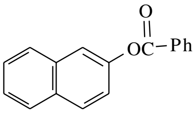
Table 1 Solvent free bromination of aromatic rings by NBS/Al_2O_3

Entry	Substrate	Product	Temperature/°C	Time/min	Yield/%[a]	M.p. or bp/Torr[c]/°C (Lit.)
1			45	5	88	82–83 (82.5)[17a]
2			45	5	90	83–84 (84)[17b]
3			45	20	63[b]	224–226 (226)[17c]
4			45	5	60	Oil[d]
5			45	5	71	77–80 (78–80)[17d]
6			25	2	77	213/760 (210/760)[17a]

---

* Correspondent. E-mail: imanzad2000@yahoo.com

Table 1 *continued*

Entry	Substrate	Product	Temperature/°C	Time/min	Yield/%[a]	M.p. or bp/Torr[c]/°C (Lit.)
7			45	20	81	200/760 (198–199)[17e]
8			45	120	73	205–207/760 (205)[17f]
9			45	120	84	211–212/760 (210)[17g]
10			25	5	86	70–73 (72–74)[17h]
11			25	5	91	100–102 (101–104)[17h]
12			25	5	85	179–181/760 (179)[17h]
13		——	60	20	——	——
14		——	100	20	——	——
15		——	60	20	——	——

[a]Yields refer to isolated products that were characterised by comparing melting points or boiling points NMR and IR spectra with authentic compounds. [b]Requires 2.4 equivalents of NBS. [c]1 Torr =133.322 Pa. [d]In this case b.p. of product could not be determined and it was characterised by NMR and IR spectra.[16]

The yield increases almost to quantitative with the alumina-supported reagent. One of the advantages of this solvent-free method is the short reaction time. As a comparison, in CH_3CN 2-methoxynaphthalene is brominated to form 1-bromo-2-methoxynaphthalene at 20 °C, in 92% yield over 3 h[16] and under the same conditions, in CCl_4 solvent, the reaction is completed in 24 h. The reaction, however, gives 90% yield by NBS-alumina under solvent-free conditions in only 5 min time at 45 °C. Our attempts to brominate naphthalene and 2,3-dihydroxynaphthalene by this reagent were unsuccessful (entries 13,14). We also studied the ring bromination of aromatic oximes with NBS-alumina, but the products obtained were the corresponding carbonyl compounds and no ring-brominated oxime was obtained at all (entries 10–12).

In conclusion, we have developed a fast, efficient and simple method for the ring bromination of a number of aromatic compounds by using alumina supported *N*-bromosuccinimide under the solvent-free conditions. The reactions were clean and no detectable by-product was formed. The product yields are good.

Experimental

All of the yields refer to isolated products. IR spectra were run on a Buck-Scientific 500 instrument. The ^1H NMR spectra were recorded on a Varian EM-390 (90 MHz) spectrometer. The melting points were determined in open capillaries with a GallenKamp Melting Point Apparatus. The purity of products was determined by a Buck Scientific 910 GC and by ^1H NMR spectroscopy. The chemicals were either prepared in our laboratories or purchased from Fluka and Merck Chemical companies.

General procedure

Alumina (neutral, 150 mesh) is dehydrated by heating to 300 °C while stirring over a Bunsen burner for 20 min. After cooling in a desiccator, the alumina is ground together with NBS (1 mmol NBS/g reagent) with a mortar and pestle for 10 min. Next, a mixture of the aromatic compound (1 mmol) and NBS/Al_2O_3 (1.7 mmol NBS, 1.7 g reagent) was thoroughly ground in an agate mortar or kept in the test-tube reactor at 25–45 °C for 2–120 min. After the reaction was complete, CCl_4 (20 ml) which does not significantly dissolve the succinimide formed, was added to the reaction mixture and after vigorous stirring at room temperature, the mixture was filtered and CCl_4 was evaporated under reduced pressure to obtained the pure brominated compound, which in the some cases could be purified further by recrystallisation from a suitable solvent.

CAUTION: Appropriate precautions must be taken because of the toxicity and environmental unfriendliness of carbon tetrachloride.

The authors thank Mohaghegh Ardebili University and Isfahan University of Technology Councils for the partial support to the work.

Received 12 April 2005; accepted 5 September 2005
Paper 05/3186

References

1 C. Christophersen, *Acta. Chem. Scand.,* 1985, **39B**, 515.
2 B.M. Chaudary,Y. Sudha and P.N. Reddy, Synlett., 1994, 450.
3 D. Roche, K. Repic and T.J. Blacklock, *Tetrahedron Lett.,* 2000, **41**, 2083.
4 K. Smith, G.A. El-Hiti, M.E.W. Hammond, D. Bahzad Z. Li and C. Siquet, *J. Chem. Soc. Perkin Trans. 1.,* 2000, 2745.
5 D. Seebach, *Angew. Chem. Int. Ed. Engl.,* 1990, **29**, 1320.
6 B. Satish Goud and G.R. Desirajau, *J. Chem. Res. (S),* 1995, 244.
7 L. Hornor and E.H. Winklemann, *Newer Methods of Preparative Organic Chemistry*, Academic Press Inc., New York, 1964, vol. 3. p. 151.
8 R. Harvelli, Jr and S.F Reed, *J. Org. Chem.*, 1968, **33**, 3976.
9 Y. Goldberg, C. Bensimon and H. Alper, *J. Org. Chem.*, 1992, **57**, 6374.
10 A.R. Hajipour, S.E. Mallakpour and G.H. Imanzadeh, *Chem. Lett.,* 1999, 99.
11 A.R. Hajipour, S.E. Mallakpour and G.H. Imanzadeh, *J. Chem. Res. (S).,* 1999, 228.
12 A.R. Hajipour, S.E. Mallakpour and G.H. Imanzadeh*, Indian J. Chem. Sect B.,* 2001, **40B,** 250.
13 A.R. Hajipour, S.E. Mallakpour and G.H. Imanzadeh, *Indian J. Chem. Sect B.,* 2001, **40B,** 237.
14 A.R. Hajipour, I. Mohammadpoor Baltork and G.H. Imanzadeh, *Synth. Commun.,* 1999, **29,** 1697.
15 M. Ghiaci and G.H. Imanzadeh, *Synth Commun*., 1998, **28,** 2275.
16 M. Carmen Carreno, J.L. Garcia Ruano, G. Sanz, M.A. Toledo and A. Urbano, *J. Org. Chem.*, 1995, **60**, 5328.
17 (a) K.J. Lee, H.K. Cho and C.E. Song, *Bull. Kor. Chem. Soc.*, 2002, **23**, 773; (b) S.E. Hazlet, *J. Am. Chem. Soc.*, 1940, **62**, 2156; (c) R. Stosser, M. Grat, H. Koppel and W. Storek, *J. Prakt. Chem.,* 1975, **317**, 591; (d) A. Manjula and A. Nagarajan., *Arkivoc* 2001, **viii**, 165; (e) G. Roques and J. Neel, *Bull. Soc. Chim. Fr.*, 1967, 3377; (f) A. Mckillop, E.C. Taylor and D. Bromley, *J. Org. Chem.* 1972, **37**, 88; (g) M. Tashiro and T. Yamato, *J. Chem. Soc. Perkin Trans. 1,* 1979, 176; (h) *Merck Catalogue/Handbook of Fine Chemicals*, 1990–91.