"Metal-free" electrooxidative C—H thiocyanation of arenes

V. A. Kokorekin,[a,b]★ E. I. Mel´nikova,[a] R. R. Yaubasarova,[a] N. V. Gorpinchenko,[b] and V. A. Petrosyan[a]

[a]N. D. Zelinsky Institute of Organic Chemistry, Russian Academy of Sciences,
47 Leninsky prosp., 119991 Moscow, Russian Federation.
Fax: +7 (499) 135 9070. E-mail: kokorekin@yandex.ru
[b]I. M. Sechenov First Moscow State Medical University
of the Ministry of Health of the Russian Federation (Sechenov University),
Build. 2, 8 ul. Trubetskaya, 119991 Moscow, Russian Federation

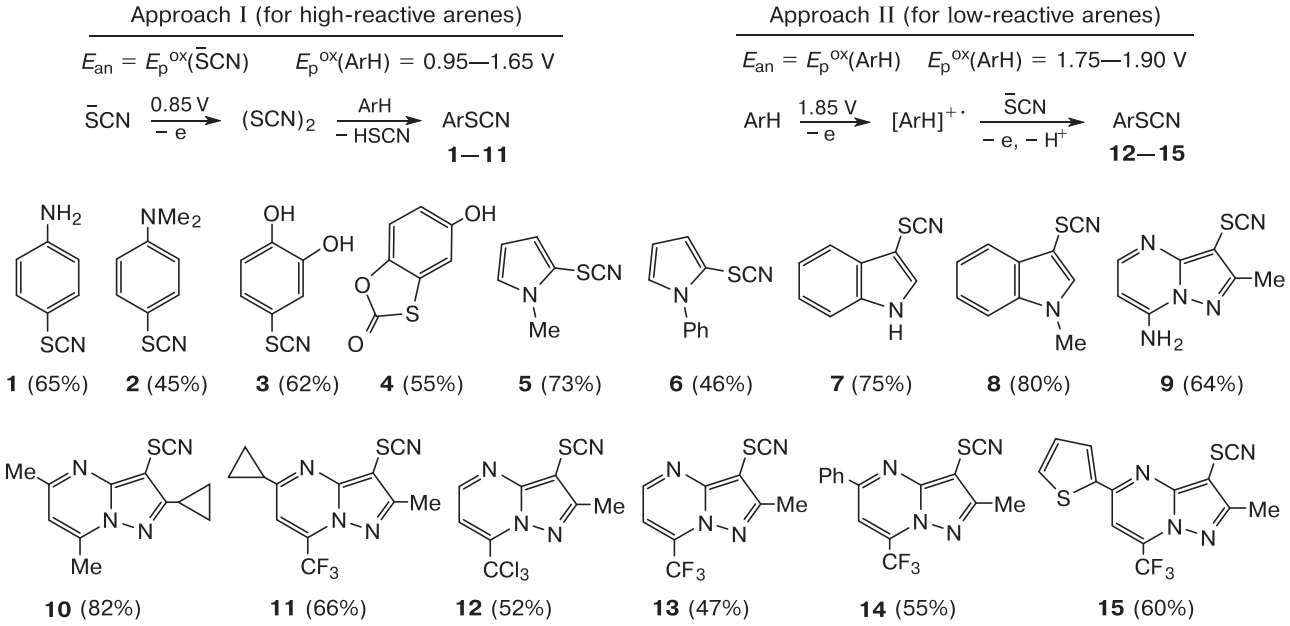
Functionally substituted arenes are structural components of numerous practically valuable compounds. Currently, the most demanded strategy for the synthesis of substituted arenes is their direct C—H functionalization.[1] The most promising trend within this strategy may involve electrooxidative (anodic) C—H functionalization,[2,3] using electric current as an available and environmentally attractive activator.

In recent years, based on anodic C—H-functionalization of arenes we developed[4—7] an effective system for electrosynthesis of aryl thiocyanates, a promising class of compounds having a wide range of pharmacological activities and being valuable precursors of sulfur-containing substances.[8,9] Meanwhile, the use of platinum electrodes essentially limited the practical attraction and innovative development of such processes. This created pre-requisites to search for more environmentally friendly and less expensive electrode materials. Earlier, for thiocyanation of 1,3,5-trimethylpyrazolo[1,5-*a*]pyrimidine, we successfully used one of such materials, namely, glassy carbon (GC).[6]

For development of these studies, there was an undoubted practical interest in using GC electrodes for synthesis of a wider range of aryl thiocyanates that we carried out *via* electrooxidative C—H thiocyanation of benzene, pyrrole, and pyrazolo[1,5-*a*]pyrimidine derivatives to yield products **1**—**15** (Scheme 1).

Electrolysis was carried out at a temperature of 20—25 °C in an undivided cell with the supporting electrolyte solution of 0.1 *M* $NaClO_4$ in MeCN (70 mL) charged with arene (1 mmol) and NH_4SCN (5 mmol) at the anode potential (E_{an}) of 0.85 V

Scheme 1



E_{an} is anode potential.

Published in Russian in *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 11, pp. 2140—2141, November, 2019.

vs. SCE (approach I, synthesis of products **1**—**11**) or 1.85 V (approach II, synthesis of products **12**—**15**). An appropriate electric charge (2—8 *F*, 193—772 C, as 1 *F* per 1 mol of thiocyanate ion or 2 *F* per 1 mol of arene) was passed for the full conversion of the starting arene: 2 *F* to yield products **1**, **5**—**9**; 4 *F* to yield products **2**—**4**, **10** and **11**; 8 *F* to yield products **12**—**15**. The treatment of the reaction mixture was similar to that represented in our prior work.[6] Earlier described target products **1**—**15** were identified by their melting points and NMR spectra according to reference data.[4,6,9—11]

In this work, we confirmed the anodic thiocyanation regularities which we found earlier.[4—7] Thus, approach I (see Scheme 1) was most effective for easily oxidizable (E_p^{ox} = 0.95—1.65 V) arenes being reactive with the electrogenerated thiocyanogen $(SCN)_2$. The yield of products **1**—**11** was 45—82%. In the case of hydroquinone, instead of aryl thiocyanate, we obtained its rearrangement product, namely, benzoxathiolone **4** (yield 52%). For hardly oxidizable (E_p^{ox} = 1.75—1.90 V) arenes being almost unreactive with $(SCN)_2$, approach II is most effective (see Scheme 1). It is accomplished at E_p^{ox} of arene *via* ECE mechanism[6] and led to target products **12**—**15** with the yields of 47—60%. Note that in some experiments we observed side processes (polymerization of thiocyanogen,[6] oxidation of starting arenes to resinous products[7], *etc.*), which caused higher electricity consumption and lowering the product yields.

Thus, this work was the first to show feasibility of "metal-free"[1] approaches to electrooxidative C—H thiocyanation of a wide range of high- and low-reactive (hetero)arenes in an undivided cell with GC electrodes. As a result, the target aryl thiocyanates **1**—**15** were synthesized with the yields of 45—82%, whereas products **2**—**4** were electrochemically obtained for the first time.

In general, our suggested tool for direct formation of C—S bonds has a number of obvious advantages (mild conditions, available and environmentally friendly materials, absence of chemical oxidants and metal-containing catalysts) that make it very promising for use in future.

This work was financially supported by the Russian Science Foundation (Project No. 19-73-20259).

References

1. V. N. Charushin, O. N. Chupakhin, *Russ. Chem. Bull.*, 2019, **68**, 453.
2. V. A. Petrosyan, *Mendeleev Commun.*, 2011, **21**, 115.
3. M. D. Karkas, *Chem. Soc. Rev.*, 2018, **47**, 5786.
4. V. A. Kokorekin, V. L. Sigacheva, V. A. Petrosyan, *Tetrahedron Lett.*, 2014, **55**, 4306.
5. V. A. Kokorekin, R. R. Yaubasarova, S. V. Neverov, V. A. Petrosyan, *Mendeleev Commun.*, 2016, **26**, 413.
6. V. A. Kokorekin, R. R. Yaubasarova, S. V. Neverov, V. A. Petrosyan, *Eur. J. Org. Chem.*, 2019, **2019**, 4233.
7. R. R. Yaubasarova, V. A. Kokorekin, G. V. Ramenskaya, V. A. Petrosyan, *Mendeleev Commun.*, 2019, **29**, 334.
8. T. Castanheiro, J. Suffert, M. Donnard, M. Gulea, *Chem. Soc. Rev.*, 2016, **45**, 494.
9. V. A. Kokorekin, A. O. Terent´ev, G. V. Ramenskaya, N. É. Grammatikova, G. M. Rodionova, A. I. Ilovaiskii, *Pharm. Chem. J.*, 2013, **47**, 422.
10. V. N. Povalishev, G. I. Polozov, O. I. Shadyro, *Bioorg. Med. Chem. Lett.*, 2006, **16**, 1236.
11. T. B. Mete, T. M. Khopade, R. G. Bhat, *Tetrahedron Lett.*, 2017, **58**, 415.

Received August 8, 2019;
in revised form August 26, 2019;
accepted September 3, 2019