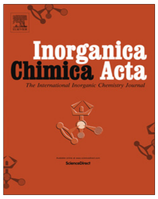
Inorganica Chimica Acta xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Inorganica Chimica Acta

journal homepage: www.elsevier.com/locate/ica



Review article

Recent advances in click chemistry reactions mediated by transition metal based systems

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ARTICLE INFO

Article history:
Received 26 February 2016
Received in revised form 12 July 2016
Accepted 18 July 2016
Available online xxxx

Keywords:
Click chemistry
Transition metals
Nanoparticles
Bioconjugation
Bioorthogonal

ABSTRACT

The recent advances of click chemistry reactions have shown that catalysts based on Cu(I) ions and nanoparticles have the potential to mediate and activate the alkyne-azide cycloaddition reactions in mild conditions and with remarkable yields. This review is focused on the recent progress recorded, over the last five years, by the transition metal catalysts in the development of novel methods and applications in the field of click chemistry reactions. Their catalytic efficiency, along with their different applications in materials, drug discovery and biological environments are also presented.

Aurel Tăbăcaru (born in 1984 in Galaţi, Romania) received his B.Sc. degree in 2008 and Master degree in 2010 from "Dunărea de Jos" University of Galaţi. In 2013, he obtained his PhD in Chemistry from the University of Camerino (Italy), working in the field of coordination polymers and metal-organic frameworks based on poly(pyrazole)-type ligands, under the supervision of Prof. Claudio Pettinari. His research career was continued with a postdoctoral fellowship at "Dunărea de Jos" University of Galaţi, working in the field of Nanotechnology, under the supervision of Prof. Viorica Muşat. In 2014, he joined the Department of Chemistry, Physics and Environment, from "Dunărea de Jos" University of Galaţi, as Teaching Assistant. His research is focused on the synthesis and study of coordination compounds (with porous, luminescent, catalytic, and antibacterial properties) and surface-modified metal oxide nanoparticles for optoelectronic applications.

Abbreviations: AOC, azide-olefin cycloaddition; APSiO$_2$, 3-aminopropyl-functionalized silica; AscNa, sodium ascorbate; aterpy, 4′-azido-2,2′:6′,2″-terpyridine; bipy, 4,4′-bipyridine; BMIM BF$_4$, 1-butyl-3-methylimidazolium tetrafluoroborate; bpoh, (N1E,N2E)-N1,N2-bis(phenyl(pyridin-2-yl)methylene)oxalohydrazide; BTRB, BisTriazole-Rhodamine B; CA153, cancer antigen 153; CL, ε-caprolactone; CH$_2$Cl$_2$, dichloromethane; CPMV, cowpea mosaic virus; CuAAC, copper-catalyzed azide-alkyne cycloaddition; CV, crystal violet; DIBO, dibenzocyclooctyne; DO3A, 1,4,7-tris(carboxymethyl)-1,4,7,10-tetraazacyclodecane; DMF, dimethylformamide; DOTA, 1,4,7,10-tetrakis(carboxymethy1)-1,4,7,10-tetraazacyclododecane; DMSO, dimethylsulfoxide; DTT, dithiothreitol; 6eBMPA, 6-ethynyl-bis(methylpyridyl)amine; ^{18}F-ArBF$_3^-$, aryltrifluoroborate; Gly, glycine; Hacac, acetylacetone; FcMeTrz-6eBMPA, triazolyl-6-ethynyl-bis(methylpyridyl)amine bearing the ferocenylmethyl moiety; GC–MS, gas chromatographic mass spectrometry; GO, graphene oxide; GTCF, graphene transparent conductive film; H$_3$Eshi, 4-ethynylsalicylhydroxamic acid; Himdc, 4,5-imidazoledicarboxylate; ^{1}H NMR, proton nuclear magnetic resonance; H$_3$TTshi, 4-(2,2′:6′,2″-terpyridyl-1H-[1,2,3]triazol-4-yl)salicylhydroxamic acid; Ln, lanthanides; 12-MC-4, 12-metallacrown-4; MCH, 6-mercapto-1-hexanol; MNPs, magnetic nanoparticles; MOFs, metal-organic frameworks; MSN, magnetic silica nanoparticles; MVS, metal vapor synthesis; NaN$_3$, sodium azide; NHC, N-heterocyclic carbene; NMe$_4$, tetramethylammonium ion; oda, oxodiacetate; NPs, nanoparticles; PEG, polyethyleneglycol; PEI, polyethyleneimine; PHEMA, poly(2-hydroxyethyl methacrylate); PhPrTrz-6eBMPA, triazolyl-6-ethynyl-bis(methylpyridyl)amine bearing the phenylpropyl moiety; PS-b-PCL, polystyrene-block-poly(ε-caprolactone); PS-OH, hydroxyl-modified polystyrene; PS-N$_3$, azide-modified polystyrene; PS-C22-CuI, polystyrene resin supported copper(I) iodide–cryptand-22 complex; PPh$_3$, triphenylphosphine; PPi, pyrophosphate ion; PVC-N$_3$, azide-modified polyvinyl chloride; PVBC, polyvinylbenzyl chloride; PVBAz, polyvinylbenzylazide; RB, glycosyl rhodamine B; ROS, reactive oxygen species; RuAAC, ruthenium-catalyzed azide-alkyne cycloaddition; SAMs, self-assembled monolayers; siRNA, small interfering ribonucleic acid; SMMs, single magnetic molecules; TBTA, tris(benzyltriazolylmethyl)amine; Thi-Fc, ferrocene-appended thiophene; tiRNA, transcription initiation ribonucleic acid; TRGO, thermally reduced graphene oxide; TMV, tobacco mosaic virus; THPTA, tris(hydroxypropyltriazolyl)methylamine; VLP, virus-like particles.

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http://dx.doi.org/10.1016/j.ica.2016.07.029
0020-1693/

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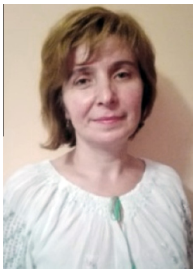
Ioana Otilia Ghinea (born in 1985 in Galați, Romania) received her B.Sc. degree in Chemistry in 2007 from the University of Bucharest. In 2014, she obtained her PhD in Biotechnology from "Dunărea de Jos" University of Galați, working in the field of biocatalysis and unconventional reaction activation techniques, under the supervision of Prof. Gabriela Bahrim. In the same year, she joined the Department of Chemistry, Physics and Environment from "Dunărea de Jos" University of Galați as Teaching Assistant in the fields of Organic and Food Chemistry. Her research is focused on cycloaddition reactions, using one-pot reactions and biocatalysis to obtain heterocyclic compounds and also on the determination of biological activity (antimicrobial, antioxidant, enzyme inhibition, protein interaction, etc.) of synthetic and natural products.

Geta Cârâc (born in 1957 in Galați, Romania) received her PhD in Materials Science in 1999 at "Dunărea de Jos" University of Galați, Romania. She is Habilitated Professor at the Department of Chemistry, Physics and Environment, from the same university. Her research is focused on applied electrochemistry: micro – nanostructured advanced materials, composite coatings, metal matrix, oxides, micro and nanoparticles, nanowires; material functional characteristics and mechanical properties; surfaces-interface chemistry; electrochemical corrosion, biocorrosion, studies of organic compounds, analytical, electrochemical and structural analysis of compounds (conventional and nonconvenational methods); food chemistry and biological analysis; environmental.



Rodica Mihaela Dinică (born in 1968 in Tecuci, Romania) received her B.Sc. degree in 1991 from "Alexandru Ioan Cuza" University of Iași (Romania). In 1999, she obtained her PhD in Chemistry from the same university, working in the field of N-heterocyclic chemistry. In 1999, she had a THEMPUS – PHARE fellowship at the Department of Chemical Sciences, University of Camerino (Italy), under the supervision of Prof. Claudio Pettinari. Her research career was continued in 2001–2002 with a postdoctoral fellowship at "Joseph Fourier" University of Grenoble, France (Laboratoire d'Etudes Dynamiques et Structurales de la Selectivite), working in the field of acridinic antitumoral compounds, under the supervision of Dr. Martine Demeunynck. From 1995, she joined the Department of Chemistry, Physics and Environment from "Dunărea de Jos" University of Galați. Since 2014, she is full professor and in 2016 she obtained the Habilitation qualification. Her research is focused on the synthesis and study of N-heterocyclic compounds with biologic activities, using click chemistry reactions, biocatalysts, ultrasound and microwave techniques.

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Please cite this article in press as: A. Tăbăcaru et al., Inorg. Chim. Acta (2016), http://dx.doi.org/10.1016/j.ica.2016.07.029