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S.D.Fazylov[1], O.A. Nurkenov[1], M.Zh. Zhurinov[3],
A.E. Arinova[1], A.R.Tuktarov[2], A.Zh.Issayeva[1], B.K.Shaihova[1]

[1]Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan;
[2]Institute of Petrochemistry and Catalysis of RAS, Ufa, Russia;
[3]Institute of Fuel, Catalysis and Electrochemistry named after D.V. Sokolsky, Almaty, Kazakhstan
e-mail: iosu8990@mail.ru, nurkenov_oral@mail.ru , arinova-anar@mail.ru , airat_1@mail.ru ,
ayauly_jan@mail.ru,dautova@mail.ru

CATALYZED BY PALLADIUM COMPLEXES THE CYCLOADDITION OF HYDRAZONES TO FULLERENEC$_{60}$

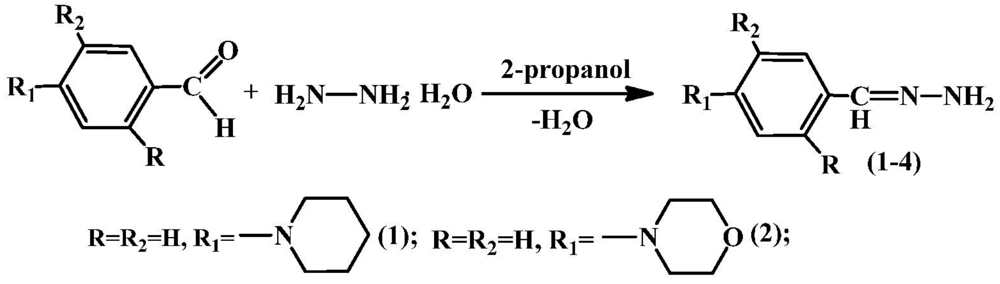
Abstract. The article is devoted to the development of a preparatively convenient method for the synthesis of new methanofullerenes by the catalytic cyclo coupling of hydrazones to fullereneC$_{60}$. The catalyst used was Pd(acac)$_2$-PPh$_3$-AlEt$_3$. The reactions were carried out under conditions of generating substituted diazomethanes in situ by oxidation of the hydrazones of the corresponding aldehydes with MnO$_2$. The use of complexes of transition metals in this reaction makes it possible to direct the cycloaddition of the diazo compounds to fullerenes towards the production of individual methanofullerenes. Initially, the synthesis of the initial arylhydrazones by the interaction of substituted benzaldehydes (salicylic aldehyde, 5-bromosalicyl aldehyde, 4-morpholino-benzaldehyde, 4-piperidine benzaldehyde) with an excess of hydrazine hydrate in isopropyl alcohol was carried out. The reaction of the reaction of diazoarylaldehydes with fullerene C$_{60}$ was monitored by HPLC. It is shown that the use of the catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$ in a ratio of 1:4:4 leads to the formation of exclusively methanofullerenes with yields of 40-95%. The composition and purity of the methanofullerenes obtained are confirmed by MALDI-TOF and HPLC mass spectrometry, and the structure by NMR^{1}H spectroscopy. The mechanism of formation of methanofullerene is discussed.

Keywords: fullereneC$_{60}$, aromatic aldehydes, diazoarylaldehydes, cycloaddition, catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$.

At present, the world science pays ever more attention to the prospects for the development of fundamental and applied research in the field of chemistry of carbon clusters. The organic chemistry of fullerene has acquired a special perspective and is developing [1,2]. The presence of a fullerene fragment in the structure of compounds provides a significant improvement or appearance of qualitatively new mechanical, chemical, physical, biological and other properties associated with the manifestation of nanoscalefactors[3], immunomodulating [4], antioxidant [5], andothertypesofactivity. Functionalization of fullerenes is mainly carried out using classical reagents and methods widely used in synthetic practice [6-13]. We previously studied the reactions of the [2 + 3]-cycloaddition-the three-component condensation of C$_{60}$ fullerene, N-methylglycine (sarcosine) and various functionally substituted aromatic aldehydes under Prato reaction conditions, leading to the formation of new fulleropyrrolidines [14-17].

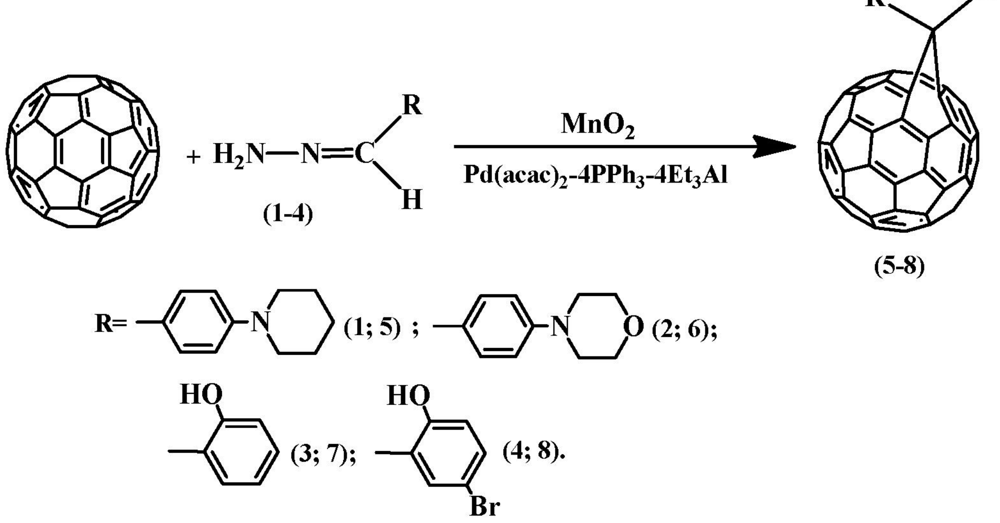
One of the most commonly used methods for the synthesis of practically important functionally substituted fullerene derivatives has been and still is the reaction of carbon clusters with *in situ* generated α-halocarbanions (the Bingel-Hirsch reaction) leading to methanofullerenes [18]. Along with this method of synthesis of fullerocyclopropanes, a wide application in synthetic practice has found methods based on cycloaddition to carbon clusters of diazocompounds.However, the main disadvantage of this reaction is its low selectivity. Meanwhile, the use of transition metal complexes in this reaction makes it possible to direct the cycloaddition of diazo compounds to fullerenes towards the production of individual methanofullerenes.

In this connection, it seemed to us of interest to study the catalytic cycloaddition of diazoarylhydrazones to C60-fullerene catalyzed by palladium complexes. Initially, we synthesized the initial arylhydrazones by the interaction of substituted benzaldehydes (salicylic aldehyde, 5-bromosalicyl aldehyde, 4-morpholinobenzaldehyde, 4-piperidine benzaldehyde) with excess hydrazine hydrate in isopropyl alcohol medium with heating for 6-10 hours. Theyieldsofhydrazones (1-4) 45-95%.



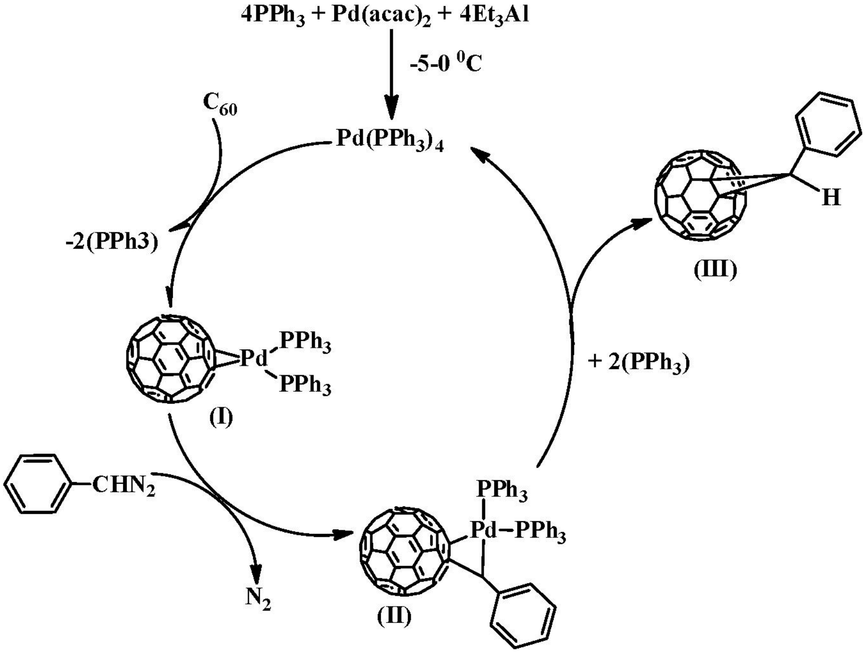
R=OH, R_1=R_2=H (3); R=OH, R_1=H, R_2=Br (4)

Next, we carried out for the first time the cyclic addition of diazoarylhydrazones (1-4) to fullerene C_{60} under the action of the three-component catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$ under the conditions of using the procedure for the generation of substituted diazomethanes by oxidation of the corresponding aldehydes with MnO$_2$. The use of the catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$ in the ratio 1:4:4 leads to the formation of methanofullerenes (5-8) with yields of 40-95%.



On the basis of the literature data, we give below a scheme-the proposed mechanism of cycloaddition of diazomethane to C_{60} involving Pd complexes. The likely mechanism of the catalytic action of the phosphine complex Pd on the cycloaddition of diazomethanes to fullerene C_{60} is based on the results of numerous experiments [19, 20].

According to the data of the authors [19, 20], the oxidative addition of fullerene C_{60} to the central catalyst atom (Pd(PPh$_3$)$_4$) proceeds to form the palladium of the cyclopropane complex C_{60}Pd (PPh$_3$) (**I**), which is confirmed by the presence of a single signal with a chemical shift δp 25.23 m. e. in the ^{1}H NMR spectrum of the complex (**I**) obtained and the color change of the fullerene solution from violet-purple to dark green. Further, diazomethane reacts with the complex (**I**) via a polarized Pd-C bond with the simultaneous elimination of N_2 and the formation of intermediate fulleropalladiumcyclobutane (**II**), which under the reaction conditions is transformed into the target methanofullerene (**III**) with regeneration of the initial Pd complex.



The reaction of diazoarylaldehydes (1-4) with fullerene C_{60} under the action of the $Pd(acac)_2$-PPh_3-$AlEt_3$catalyst was monitored by HPLC. The reaction products were analyzed on an Altex chromatograph (model 330) (USA) with a UV detector at a wavelength of 313 nm. Figure 1 shows the chromatograms of Compound (5) for the reaction time in 2 h and 4 h.

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C-R8A CHROMATOPAC CH=1  Report No.=5   DATA=1:@CHRM1.C00   13/04/21  12:52:44

** CALCULATION REPORT **
CH PKNO  TIME     AREA    HEIGHT  MK  IDNO   CONC       NAME
1    1   0.05      341      506              0.0238
     2   3.026    2698      843              0.1882
     3   4.425   12969     1953              0.9046
     4   5.083    6783      606              0.4731
     5   5.434  170985    21006   V         11.9273
     6   5.631  324025    15589   V         22.6028
     7   6.821  763194    55193             53.2376
     8   8.647  152568    12466             10.6426
         ---------------------------------------------
      TOTAL    1433562   108162              100
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C-R8A CHROMATOPAC CH=1  Report No.=12  DATA=1:@CHRM1.C00   13/04/24  17:23:10

** CALCULATION REPORT **
CH PKNO  TIME     AREA    HEIGHT  MK  IDNO   CONC       NAME
1    1   5.601  551809    74188             95.0976
     2   6.81    28446     3187              4.9024
         ---------------------------------------------
      TOTAL     580255    77374              100
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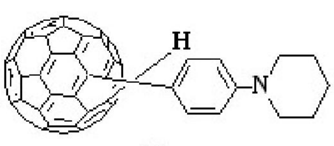
A B

Figure 1 - Chromatograms of compound (5): A - after 2 h; (B) - after 4 h



(5)

The structure of the compounds obtained was studied using 1- (4- (piperidine) phenyl)-1aH-1(2)a-homo(C60-Ih) [5,6] fullerene (5) using mass spectrometry (MALDI-TOF/TOF). Mass spectra (5) contain peaks of molecular ions with m / z 892.097 (calculated at 893.120) (Fig. 2).

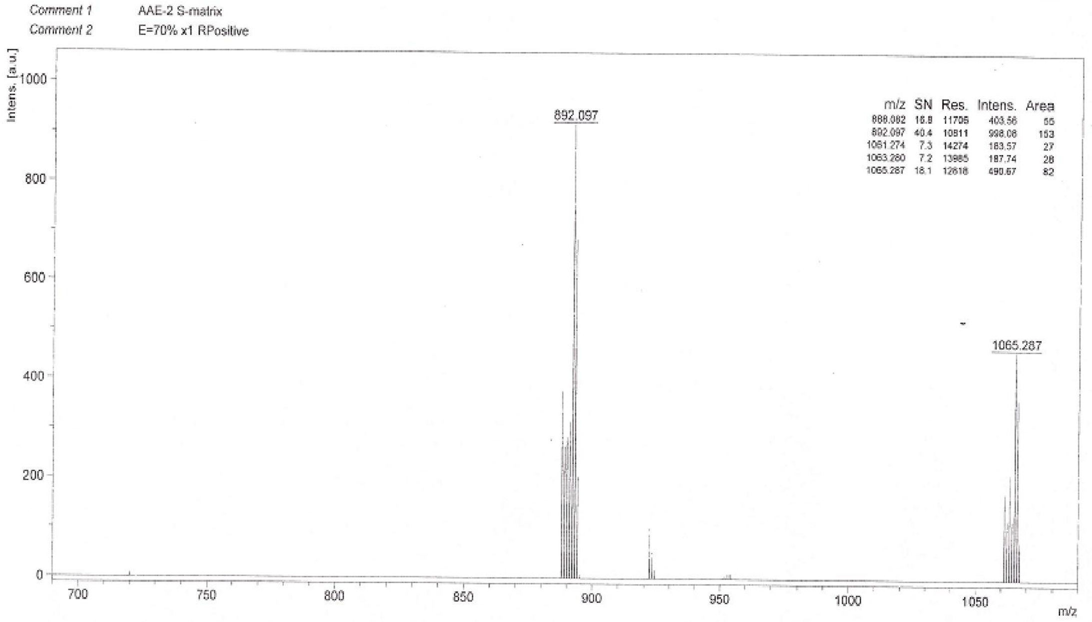


Figure 2 - Mass spectrum of 1-(4-(piperidine)phenyl)-1aH-(2)a-homo(C$_{60}$-I$_h$) [5,6] fullerene (5)

Thus, the synthesis was carried out and the catalytic cycloaddition of arylhydrazones to C$_{60}$ fullerene was carried out using the metal complex catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$. It is shown that the use of the catalyst Pd(acac)$_2$-PPh$_3$-AlEt$_3$ in a ratio of 1: 4: 4 leads to the formation of exclusively methanofullerenes with yields of 40-95%. The proposed method is based on the generation of diazoalkanes in situ by oxidation of arylhydrazones with MnO$_2$ and using catalytic amounts of the palladium complex, the reaction is carried out at room temperature in a solution of o-dichlorobenzene.

Experimental part

The ^{1}H NMR spectrum of compounds (5) was taken on a JEOLFX90Q spectrometer (90 and 22 MHz). The analysis of addition products was carried out by HPLC on an Altex chromatograph (model 330) (USA) with a UV detector at a wavelength of 313 nm. The components of the mixture were separated on a metal column of 250x8 mm PLgel 100 Å with sorbent grains 5 mkm at room temperature. The mobile phase is toluene, the flow rate is 0.2 ml/min. Mass spectra were obtained on a MALDI-TOF/TOF instrument.

1-(4-(Hydrazonomethyl) phenyl) piperidine (1). To a solution of 0.2 g (0.001 mol) of 4-(piperidin-1-yl)benzaldehyde in 10 ml of 2-propanol, 0.25 g (0.005 mol) hydrazine hydrate. The reaction mixture was heated at 70 °C for 3-4 h. The precipitate which formed was filtered off, washed with 2-propanol and recrystallized from 2-propanol, 0.19 g (95%) of compound (1) was obtained, m.p. 155-156 °C. Found (%): C, 70.95; H, 8.48; N, 20.72. $C_{12}H_{17}N_3$. Calculated (%): C, 70.90; H, 8.43; N, 20.67.

4-(4-(Hydrazonomethyl)phenyl)morpholine (2) was prepared analogously to compound (1) from 1 g (0.005 mol) of 4-morpholylbenzaldehyde and 1.3 g (0.026 mol) of hydrazine hydrate. 0.83 g (81%) of the compound (2.23) is obtained, m.p. 159-160^{0}C. Found (%): C, 64.42; H, 7.42; N, 20.52. $C_{11}H_{15}N_3O$. Calculated (%): C, 64.37; H, 4.37; N, 20.47.

2-(Hydrazonomethyl) phenol (3) was prepared analogously to compound (1) from 2 g (0.0164 mol) of salicylic aldehyde and 4.1 g (0.082 mol) of hydrazine hydrate. 1 g (45%) of the compound (3.24) was obtained, m.p. 82°C. Found (%): C, 61.80; H, 5.97; N, 20.63. $C_7H_8N_{20}$. Calculated (%): C, 61.75; H, 5.92; N, 20.58.

5-**Bromo-2-(hydrazonomethyl) phenol (4)** was prepared analogously to compound (1) from 1 g (0.005 mol) of 5-bromo-2-hydroxybenzaldehyde and 1.24g (0.025 mol) of hydrazine hydrate. 0.6 g (56%)

of the compound (3.25) is obtained, m.p. 247^{0}C. Found (%): C, 39.15; H, 3.33; N, 13.08. $C_7H_7N_2OBr$. Calculated (%): C, 39.10; H, 3.28; N, 13.03.

1-(4-(piperidine)phenyl)-1aH-1(2)a-homo(C_{60}-I_h)[5,6]-fullerene (5). A solution containing 0.1 ml (0.00278 mmol) of $Pd(acac)_2$ in 0.4 ml of o-dichlorobenzene and 0.2 ml (0.00556 mmol) of PPh_3 in 0.42 ml of o-dichlorobenzene was charged to the glass reactor. In dry argon flow at -5°C and with stirring, 0.4 ml (0.01112 mmol) of Et_3Al in 0.1 ml of toluene was added, while the color from slightly yellow to slightly brown. 10 mg (0.0139 mmol) of C_{60} fullerene in 2 ml of chlorobenzene were added to the obtained catalyst at room temperature, and the solution acquired a dark green color. 8.46 mg (0.0417 mmol) of 1-(4-(hydrazonomethyl)phenyl) piperidine were added to the resulting fullerene complex in 9.4 ml of CH_2Cl_2 and in small portions 0.2 mmol of MnO_2. After 1 hour, the reaction mass was treated with an aqueous solution of 5% HCl, 7 ml of toluene was added and the organic layer was passed through a column with a small amount of silica gel. The reaction products and the C_{60} fullerene were separated by preparative HPLC, eluent-toluene. The product was a brown powdered substance 11.4 mg (95%).

1-(4-(Morpholyl)-phenyl)-1a*H*-1(2)a-homo(C_{60}-I_h)[5,6]fullerene(6), 1-(4-(2-hydroxyphenyl)-1aH-1(2)a-homo(C60-Ih)[5,6] fullerene (7) and 1-(4-(5-bromo-2-hydroxy-phenyl)-1aH-1(2)a-homo(C_{60}-I_h)[5,6] fullerene (8) were prepared analogously to compound (5) and are brown powders with yields of 95%, 45% and 51%, respectively.

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REFERENCES

[1] Fullerenes: Textbook / Ed. L.N. Sidorova, M.A. Yurovsky and others - M .: Publishing house "Examen", **2005**. 688 p. (In Russian).

[2] Karakulova E.N., Bagriy E.I. Fullerenes: methods of functionalization and prospects for the application of derivatives // Usp. chemistry. **1999**. T. 68. N 11.P. 979-998.(In Russian).

[3] Bosi S., Da Ros T., Spalluto G., Balzarini J., Prato M. Synthesis and Anti-HIV properties of new water-soluble bis-functionalized [60] fullerene Derivatives // Bioorg. Med. Chem. Lett. **2003**.Vol. 13. P. 4437-4440.DOI:10.1016/j.bmcl.2003.09.016.(In Eng).

[4] Bosi S., Da Ros T., Castellano S., Bafni E., Prato M. Antimycobacterial activity of ionic fullerene derivatives. // Bioorg. Med. Chem. Lett. **2000**.Vol. 10.P. 1043-1045.DOI: 10.1016/S0960-894X(00)00159-1. (In Eng).

[5] Hirsch A., Li Q., Wudl F. Globe-trotting hydrogenes on the surface of the fullerene compound $C_{60}H_6$ $(N(CH_2CH_2)_2O)_6$ // Angew. Chem. Int. Ed.**1991**.Vol. 30.P. 1309-1310.DOI: 10.1002/anie.199113091. (In Eng).

[6] Yurovskaya M.A., Trushkov I.V. Reactions of cycloaddition to bakminster fullerene C60: achievements and prospects //Russ. Chemical Bulletin **2002**.№3.C. 343-414.DOI:10665285/02/5103367 $27.00.(In Russian).

[7] Nuretdinov I.A., Gubskaya V.P., Berezhnaya L.Sh., Ilyasov A.V., Azaneev N.M. Synthesis of phosphorylated methnofullerenes // Russ. Chemical Bulletin. **2000**.T.49. P. 2083-2086.DOI: 1066-5285/00/4912-2048 S25.00. (In Russian)

[8] Mashino T., Nishikawa D., Takanashi K., Usui N., Yamori T., Seki M., Endo T., Mochizuki M. Antibacterial and antiproliferative activity of cationic fullerene derivatives // Bioorg. Med. Chem. Lett. **2003**. Vol. 13. P. 4395-4397.DOI: 10.1016/j.bmcl.2003.09.040. (In Eng).

[9] Butts C. P., Havenith W.A., Jazdzyk M., Drewello T., Kotsiris S. The structure and first ^{1}H NMR spectral assignment of piperazine - C60 adducts // Tetrahedron Lett. **2003**. Vol. 44 P. 3565-3567.DOI:10.1016/S0040-4039(03)00624-5. (In Eng)

[10] Markus Y., Smith A.L., Korobov M.V., Mirakyan A.L., Avramenko N.M., Stukalin E.B. Solbulityof C-60 fullerene // J. Chem. **2001**. Vol. 105.P. 2499-2506. (In Eng)

[11] Wharton T., Wilson L.J. Highly-iodinated fullerene as contracts agent for X-ray imaging // Bioorg. Med. Chem. Lett. **2002**. Vol. 10. P. 3545-3554.(In Eng).

[12] Hirsch A., Li Q., Wudl F. Globe-trotting hydrogenes on the surface of the fullerene compound $C_{60}H_6(N(CH_2CH_2)_2O)_6$ // Angew. Chem. Int. Ed. **1991**. Vol.30. P. 1309-1310.DOI: 10.1002/anie.199113091.(In Eng).

[13] Fong R., Schuster D.I., Wilson S.R. Synthesis and photophysical properties of steroid-linked porphyrin -fullerene hybrids // Org. Lett. **1999**. Vol. 1. P. 729-732.DOI: 10.1021/ol990722z.(In Eng).

[14] Fazylov S.D., Nurkenov O.A., Arinova A.E., Tuktarov A.R., Khuzin A.A., TurdybekovK.M. Synthesis and structure of N-methyl-1-[phenyl]fullerene-C60[1,9c]-pyrrolidines based on aminoaldehyde // Russ. J. Gen. Chem. **2014**. T. 84. N. 10. P. 1757-1758.DOI: 10.1134/S1070363214100375. (In Russian).

[15] Fazylov S.D., NurkenovO.A., Arinova A.E., Seilkhanov T.M., Tuktarov A.R., Khuzin A.A., Bakirova R.E., Muravleva L.E. Synthesis and structure of N-methyl-1-[(4-bromo-3,5-dimethyl-1H-pyrazol-1-yl) phenyl]fullerene with 60-[1,9-c] pyrrolidine //Russ. J. Gen. Chem. **2015**. T.85. Vol. 5.P.751-754.DOI: 10.1134/S1070363215050072.(In Russian).

[16] Fazylov S.D. Organic derivatives of fullerene - a new class of compounds with the prospect of using in medicine // Reports of NAS RK. **2014**. N 6. P. 41-49.(In Russian).

[17] Fazylov S.D., Nurkenov O.A., Zhivotova T.C., ArinovaA.E. Synthesis and structure of N-methyl-1- [R-phenyl] fullerene-C60[1,9c]pyrrolidines // Chemical Journal of Kazakhstan. **2013**.N 2 (42). P. 136-124.(In Russian)

[18] Tuktarov A.R., Korolev V.V., Tulyabayev A.R., Yanybin V.M., Khalilov L.M., Dzhemilev U.M. Cycloaddition of cyclic diazo compounds to fullerene C60 in the presence of a Pd-containing complex catalyst.//Russ. Chemical Bulletin. **2010**. N 5. P. 956-962.DOI: 10665285/10/59050977. (In Russian).

[19] Tuktarov A.R., Akhmetov A.R., Khalilov L.M., Dzhemilev U.M. Catalytic cycloaddition of diazoketones to fullerene C60 // Russ. Chemical Bulletin. 2010. N 3.P. 598.DOI: 10665285/10/59030611. (In Russian).

[20] Tuktarov A.R., Akhmetov A.R., Khasanova L.L., Khalilov L.M., Dzhemilev U.M. Cycloaddition of Diazoacetic Esters to C60 Fullerene Catalyzed by Pd Complexes. // Russ. Chemical Bulletin. **2010**. N 10. P. 1909-1913.DOI: 10665285/10/59101959. (In Russian).

С.Д.Фазылов[1], О.А.Нүркенов[1], М.Ж. Журинов[3], А.Е.Әрінова[1],
А.Р.Туктаров[2], А.Ж. Исаева[1], Б.К.Шаихова[1]

[1]ҚР Органикалық синтез және көмірхимияинститута, Қарағанды, Қазахстан;
[2]РҒА Мұнайхимия және катализ институті,Уфа, Ресей;
[3]Д.В. Сокольский атындағыОтын, катализ және электрохимияинституты, Алматы, Қазахстан

C_{60} ФУЛЛЕРЕНГЕ ГИДРАЗОНДАРДЫҢ ПАЛЛАДИЙ КОМПЛЕСТЕРІМЕН КАТАЛИЗДЕНЕТІН ЦИКЛОҚОСЫЛУЫ

Аннотация. Мақала C_{60}-фуллеренге гидразондарды каталитикалық циклоқосумен жаңа метанофуллерендер синтезінің препаратты тиімді әдісін әзірлеуіне арналған. Катализатор ретінде композициялық катализатор $Pd(acac)_2$-PPh_3-$AlEt_3$ қолданылды. Реакциялар MnO_2 көмегімен сәйкес альдегидтертің гидразондарының тотығуы нәтижесінде орынбасылған диазометандардың *in situ* генерациялануы әдісін қолдану жағдайында жүргізілді. Ауыспалы металдардың комплекстерінің қолданылуыдиазоқосылыстардың фуллеренге циклоқосылуреакциясын жеке метанофуллерендерді алубағыттынқамтамасыз етеді. Алдымен изопропилді спирт ортасында гидразингидраттың артық мөлшері қатысында орын басылған бензальдегидттермен (салицил альдегиді, 5-бромсалицилді алдегид, 4-морфолинобензальдегид, 4-пиперидинбен-зальдегид)әрекеттесуі нәтижесінде бастапқы арилгидразондар синтезі жүргізілді. Диазоарилальдегид-тердің фуллерен C_{60}-пен әрекеттестіру реакциясын ЖТСХ арқылы тексеріліп отырылды. $Pd(acac)_2$-PPh_3-$AlEt_3$ катализаторын 1:4:4 қатысында қолдану тек қана метано-фуллерендердің 40-95% шығыммен түзілуіне әкелетінікөрсетілді. Алынған метнофуллерендердің құрылымы ЯМР^{1}Hспектро-скопиямен, құрамы мен тазалығы масс-спектрометрия MALDI-TOF және ЖТСХ әдістерімен расталған.Метанофуллереннің түзілуінің механизмі талқынылады.

Түйін сөздер: C_{60}-фуллерен, ароматтық альдегидтер, диазоарилальде-гидтер, циклоқосылу, катализатор $Pd(acac)_2$-PPh_3-$AlEt_3$.

С.Д. Фазылов[1], О.А. Нуркенов[1], М.Ж. Журинов[3], А.Е. Аринова[1],
А.Р. Туктаров[2], А.Ж. Исаева[1], Б.К. Шаихова[1]

[1]Институт органического синтеза и углехимии РК, Караганда, Казахстан;
[2]Институт нефтехимии и катализа РАН, Уфа, Россия;
[3]Институт топлива, катализа и электрохимии им. Д.В. Сокольского, Алматы, Казахстан

КАТАЛИЗИРУЕМОЕ КОМПЛЕКСАМИ ПАЛЛАДИЯЦИКЛОПРИСОЕДИНЕНИЕ ГИДРАЗОНОВ К ФУЛЛЕРЕНУ C_{60}

Аннотация. Статья посвящена разработке препаративно удобного способа синтеза новых метанофуллеренов каталитическим цикло присоединением гидразонов к фуллеренуC_{60}. В качестве катализатора использовалась композиция $Pd(acac)_2$-PPh_3-$AlEt_3$. Реакции проводились в условиях генерирования замещенных диазометанов*insitu* окислением гидразонов соответствующих альдегидов с помощью MnO_2. Использование комплексов переходных металлов в этой реакции позволяет направить циклоприсоединениедиазосоединений к фуллеренам в сторону получения индивидуальных метанофуллеренов. Вначале осуществлен синтез исходныхарилгидразонов взаимо-действием замещенных бензальдеги-дов (салициловый альдегид, 5-бромсалициловый альдегид, 4-морфолино-бензальдегид, 4-пиперидинбензальдегид) с избытком гидразингидрата в среде изопропилового спирта. Реакцию взаимодействия диазоарилальдегидов с фуллереном C_{60} контролировали методом ВЭЖХ. Показано, что исполь-зование катализатора $Pd(acac)_2$-PPh_3-$AlEt_3$ в соотношении 1:4:4 приводит к образованию исключительно метано-фуллеренов с выходами 40-95%. Состав и чистота полученных метанофуллеренов подтверждены данными масс-спектрометрии MALDI-TOF и ВЭЖХ, а строение - методом ЯМР^{1}H-спектроскопии. Обсуждается механизм образования метанофуллерена.

Ключевые слова: C_{60}-фуллерен, ароматические альдегиды,диазоарилальдегиды, циклоприсоединение, катализатор $Pd(acac)_2$-PPh_3-$AlEt_3$.

Information about authors:

Fazylov S.D.- Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan;
Nurkenov O.A. - Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan;
Zhurinov M.Zh. - Institute of Fuel, Catalysis and Electrochemistry named after D.V. Sokolsky, Almaty, Kazakhstan;
Arinova A.E. - Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan;
Tuktarov A.R.- Institute of Petrochemistry and Catalysis of RAS, Ufa, Russia;
Issayeva A.Zh. - Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan;
Shaihova B.K. - Institute of Organic Synthesis and Coal Chemistry of the Republic of Kazakhstan, Karaganda, Kazakhstan.