

# Søren Møller

## C<sub>60</sub>: Buckminsterfulleren

-En litteraturliste fra Roskilde Universitetsbibliotek

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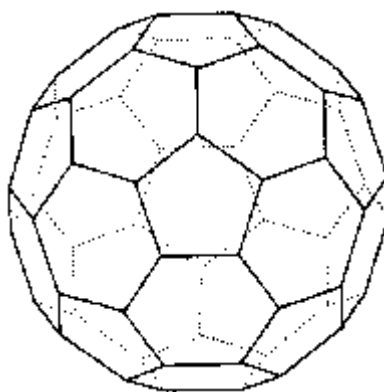
[4. Konferencer](#)

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### 1. Indledning

I 1985 publiceredes i det yderst ansete engelske tidsskrift Nature en lille to-siders artikel med titlen C<sub>60</sub>:Buckminsterfullerene (Kroto, H.W.; Heath, J.R.; O'Brien, S.C.; Curl, R.F.; Smalley, R.E.: *Nature*, **318**, 162-3, 1985). Hermed var startskuddet gået for en nærmest eksplosionsagtig interesse for denne nye form for kulstof, som hverken kan beskrives som grafit eller diamant. Navnet buckminsterfulleren blev valgt til ære for en berømt amerikansk arkitekt (R. Buckminster Fuller, 1895-1983), som til verdensudstillingen i Montreal i 1967 konstruerede en stor gennemsigtig kugle bygget op af fem- og sekskanter, nøjagtig som en fodbold. Navne som ballene, spherene, soccerene og carbosoccer blev da også foreslået af forfatterne. Den endelige bekræftelse af strukturen kom med publikationen af det første <sup>13</sup>C-NMR spektrum af C<sub>60</sub> (Taylor, R.; Hare, J.P.; Abdul-Sada, A.K.; Kroto, H.W.: *J.Chem.Soc., Chem.Commun.*, 1423-25, No.20, 1990).

Buckminsterfulleren er blot eet molekyle (omend usædvanligt stabilt) ud af en klasse af kugleformede kulstofmolekyler, C<sub>n</sub>, hvor n=20-200 (ca.). Denne klasse kaldes med et fælles navn fullerener.



**C<sub>60</sub>: Buckminsterfulleren**

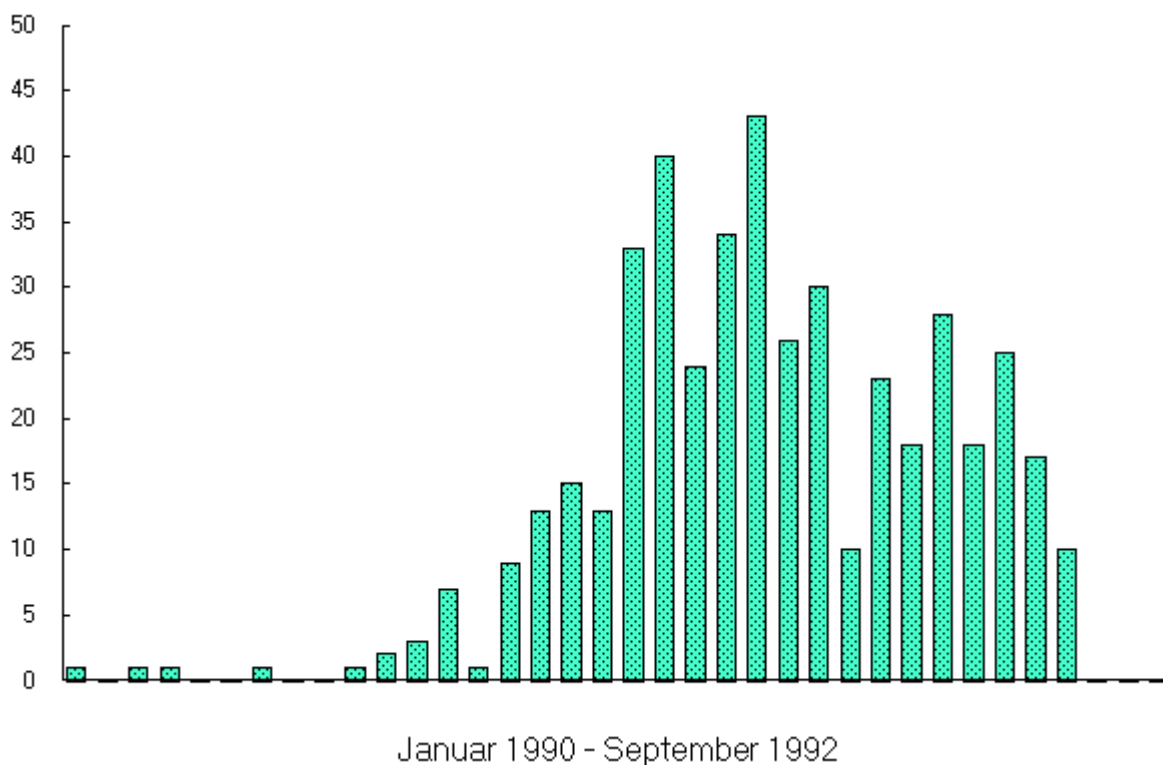
Der er til dato blevet citeret ca. 850 artikler i Chemical Abstracts hvor CAS-nummeret [99685-96-8] for C<sub>60</sub> indgår. Figur 1 viser antallet af C<sub>60</sub> artikler citeret i *Current Contents* fordelt på udgivelsesmåned i perioden fra januar 1990 til dato.

Interessen samlede sig i begyndelsen om verifikation af strukturen, men siden er der publiceret artikler om bl.a. C<sub>60</sub>'s optræden i det interstellare verdensrum, kemiske reaktioner med C<sub>60</sub>, C<sub>60</sub> som 'cage'-molekyle og C<sub>60</sub> som superleder. Anvendelser for C<sub>60</sub> kan man P.T. kun spekulere om, men der har været foreslået oplagte muligheder som f.eks. komponent i smøremidler, transportør af radioaktive metalatomer i organismen i

forbindelse med sygdomsbehandling og som forstadie ved fremstilling af kunstige diamanter. I Danmark foregår  $C_{60}$  forskningen især på Forskningscenter Risø, hvor man har den (vistnok) eneste facilitet i Europa til fremstilling af stoffet i ren form.

I denne litteraturliste for  $C_{60}$  er samlet publikationer af mere eller mindre populær karakter (kapitel 2), en komplet liste af  $C_{60}$  artikler publiceret i *Nature* og *Science* (kapitel 3) og konferencer (kapitel 4). De to tidsskrifter *Nature* og *Science* er valgt fordi de bringer de nyeste og mest markante forskningsresultater.

Al litteratur medtaget i denne liste haves på **RUb** eller er under anskaffelse. God fornøjelse med dette spændende nye emne.



Figur 1.  $C_{60}$  artikler citeret i *Current Contents* i perioden januar 1990 til september 1992.

## 2. Publikationer af populær karakter

**Larsen, E.; Egsgaard, H.; Skytte Jensen, B.; Bohr, J.**  
 $C_{60}/C_{70}$ , Fysik og Kemi.  
 Dansk Kemi **6/7**, 10-13, 1992.

**Sveinsdottir, S.**  
 Spillet om fodboldkulstof er igang.  
 Ingeniøren nr. **7**, 12-13, 1992

**Schmidt, O.H.; Strand, J.; Rasmussen, J.**  
 Dannelse af Fullerener.  
 Projekt rapport, Den naturvidenskabelige basisuddannelse,  
 Roskilde Universitetscenter (dupl.), 1992.

Enkel syntes av nytt kol sätter fart på forskarna  
 Kemisk Tidskrift nr. **1**, 7, 1991

**Kroto, H.W.**  
 $C_{60}$ : Buckminsterfulleren, die Himmelssphäre, die zur Erde fiel.

Angewandte Chemie, **104**, 113-133, 1992

**Smalley, R.E.**

Great Balls of Carbon: The Story of Buckminsterfullerene.  
The Sciences, **31**, 22-28, 1991

**Baggott, J.**

Great Balls of Carbon.  
New Scientist, **131**, 34-38, 1991

**Curl, R.F.; Smalley, R.E.**

Fullerenes.  
Scientific American 32-41, October 1991

### 3. Artikler i Nature og Science

#### Artikler i Nature i kronologisk orden

**Wang, Y.**

Photoconductivity of fullerene-doped polymers  
Nature, **356**, 585-7, 1992

**Tanigaki, K.; Hirose, I.; Ebbesen, T. W.; Mizuki, J.; Shimakawa, Y.; Kubo, Y.; Tsai, J. S.; Kuroshima, S.**

Superconductivity in sodium- and lithium-containing alkali-metal fullerenes  
Nature, **356**, 419-21, 1992

**Rosseinsky, M. J.; Murphy, D. W.; Fleming, R. M.; Tycko, R.; Ramirez, A. P.; Siegrist, T.; Dabbagh, G.; Barrett, S. E.**

Structural and electronic properties of sodium-intercalated fullerene C<sub>60</sub>  
Nature, **356**, 416-18, 1992

**Tutt, Lee W.; Kost, Alan**

Optical limiting performance of C<sub>60</sub> and C<sub>70</sub> solutions  
Nature, **356**, 225-6, 1992

**Zhu, Qing; Cox, David E.; Fischer, John E.; Kniaz, Krzysztof; McGhie, Andrew R.; Zhou, Otto**

Intercalation of solid C<sub>60</sub> with iodine  
Nature, **355**, 712-14, 1992

**Nunez Regueiro, Manuel; Monceau, Pierre; Hodeau, Jean Louis**

Crushing C<sub>60</sub> to diamond at room temperature  
Nature, **355**, 237-9, 1992

**Nunez Regueiro, M.; Monceau, P.; Rassat, A.; Bernier, P.; Zahab, A.**

Absence of the metallic phase at high pressures in fullerene (C<sub>60</sub>)  
Nature, **354**, 289-91, 1991

**David, William I. F.; Ibberson, Richard M.; Matthewman, Judy C.; Prassides, Kosmas; Dennis, T. John S.; Hare, Jonathan P.; Kroto, Harold W.; Taylor, Roger; Walton, David R. M.**

Crystal structure and bonding of ordered carbon cluster C<sub>60</sub>  
Nature, **353**, 147-9, 1991

**Ansaldo, E. J.; Niedermayer, C.; Stronach, C. E.**

Muonium in fullerite  
Nature, **353**, 121, 1991

**Fleming, R. M.; Ramirez, A. P.; Rosseinsky, M. J.; Murphy, D. W.; Haddon, R. C.; Zahurak, S. M.; Makhija, A. V.**

Relation of structure and superconducting transition temperatures in  $A_3C_{60}$  (alkali-metal-doped fullerenes)  
Nature, **352**, 787-8, 1991

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**Rosseinsky, M. J.; Ramirez, A. P.; Murphy, D. W.; Tully, J. C.; Haddon, R. C.; Siegrist, T.; Tycko, R.; Glarum, S. H.; et al.**

Preparation and structure of the alkali-metal fulleride  $A_4C_{60}$  Fleming, R. M.;  
Nature, **352**, 701-3, 1991

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**Uemura, Y. J.; Keren, A.; Le, L. P.; Luke, G. M.; Sternlieb, B. J.; Wu, W. D.; Brewer, J. H.; Whetten, R. L.; Huang, S. M.; et al.**

Magnetic-field penetration depth in potassium doped fullerene ( $K_3C_{60}$ ) measured by muon spin relaxation  
Nature, **352**, 605-7, 1991

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**Chen, C. T.; Tjeng, L. H.; Rudolf, P.; Meigs, G.; Rowe, J. E.; Chen, J.; McCauley, J. P., Jr.; Smith, A. B., III; McGhie, A. R.; et al.**

Electronic states and phases of  $K_xC_{60}$  from photoemission and x-ray absorption spectroscopy  
Nature, **352**, 603-5, 1991

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**Kelty, Stephen P.; Chen, Chia Chun; Lieber, Charles M.**

Superconductivity at 30 K in cesium-doped fullerene  
Nature, **352**, 223-5, 1991

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**Howard, Jack B.; McKinnon, J. Thomas; Makarovskiy, Yakov; Lafleur, Arthur L.; Johnson, M. Elaine**

Fullerenes  $C_{60}$  and  $C_{70}$  in flames  
Nature, **352**, 139-41, 1991

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**Guo, Yuejin; Karasawa, Naoki; Goddard, William A., III**

Prediction of fullerene packing in  $C_{60}$  and  $C_{70}$  crystals  
Nature, **351**, 464-7, 1991

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**Hebard, A. F.; Rosseinsky, M. J.; Haddon, R. C.; Murphy, D. W.; Glarum, S. H.; Palstra, T. T. M.; Ramirez, A. P.; Kortan, A. R.**

Superconductivity at 18 K in potassium-doped fullerene ( $C_{60}$ )  
Nature, **350**, 600-1, 1991

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**Haddon, R. C.; Hebard, A. F.; Rosseinsky, M. J.; Murphy, D. W.; Duclos, S. J.; Lyons, K. B.; Miller, B.; Rosamilia, J. M.; Fleming, R. M.; et al.**

Conducting films of  $C_{60}$  and  $C_{70}$  by alkali-metal doping  
Nature, **350**, 320-2, 1991

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**Haddon, R. C.; Schneemeyer, L. F.; Waszczak, J. V.; Glarum, S. H.; Tycko, R.; Dabbagh, G.; Kortan, A. R.; Muller, A. J.; Mujsce, A. M.; et al.**

Experimental and theoretical determination of the magnetic susceptibility of  $C_{60}$  and  $C_{70}$   
Nature, **350**, 46-7, 1991

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**Wragg, J. L.; Chamberlain, J. E.; White, H. W.; Kraetschmer, W.; Huffman, Donald R.**

Scanning tunnelling microscopy of solid  $C_{60}/C_{70}$   
Nature, **348**, 623-4, 1990

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**Wilson, R. J.; Meijer, G.; Bethune, D. S.; Johnson, R. D.; Chambliss, D. D.; De Vries, M. S.; Hunziker, H. E.; Wendt, H. R.**

Imaging  $C_{60}$  clusters on a surface using a scanning tunnelling microscope  
Nature, **348**, 621-2, 1990

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**Kraetschmer, W.; Lamb, Lowell D.; Fostiropoulos, K.; Huffman, Donald R.**

Solid  $C_{60}$ : a new form of carbon  
Nature, **347**, 354-8, 1990

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**Kroto, H. W.**

The stability of the fullerenes  $C_n$ , with  $n = 24, 28, 32, 36, 50, 60$  and  $70$   
*Nature*, **329**, 529-31, 1987

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**Elser, V.; Haddon, R. C.**

Icosahedral  $C_{60}$ : an aromatic molecule with a vanishingly small ring current magnetic susceptibility  
*Nature*, **325**, 792-4, 1987

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**Klein, D. J.; Seitz, W. A.; Schmalz, T. G.**

Icosahedral symmetry carbon cage molecules  
*Nature*, **323**, 703-6, 1986

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**Kroto, H. W.; Heath, J. R.; O'Brien, S. C.; Curl, R. F.; Smalley, R. E.**

$C_{60}$ : buckminsterfullerene  
*Nature*, **318**, 162-3, 1985

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**Artikler i Science i kronologisk orden****Alers, G. B.; Golding, Brage; Kortan, A. R.; Haddon, R. C.; Theil, F.A.**

Existence of an orientational electric dipolar response in fullerene ( $C_{60}$ ) single crystals  
*Science*, **257**, 511-14, 1992

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**Buseck, Peter R.; Tsipursky, Semeon J.; Hettich, Robert**

Fullerenes from the geological environment  
*Science*, **257**, 215-17, 1992

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**Tebbe, Fred N.; Harlow, Richard L.; Chase, D. Bruce; Thorn, David, L.; Campbell, G. Creston, Jr.; Calabrese, Joseph C.; Herron, Norman; Young, Robert J., Jr.; Wasserman, E.**

Synthesis and single-crystal x-ray structure of a highly symmetrical fullerene ( $C_{60}$ ) derivative, brominated fullerene ( $C_{60}Br_{24}$ )  
*Science*, **256**, 822-5, 1992

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**Johnson, Robert D.; Yannoni, Costantino S.; Dorn, Harry C.; Salem, Jesse R.; Bethune, Donald S.**

Buckminsterfullerene ( $C_{60}$ ) rotation in the solid state: dynamics of a faceted spherical top  
*Science*, **255**, 1235-8, 1992

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**Kochanski, G. P.; Hebard, A. F.; Haddon, R. C.; Fiory, A. T.**

Electrical resistivity and stoichiometry of  $K_xC_{60}$  films  
*Science*, **255**, 184-6, 1992

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**Duclos, S. J.; Haddon, R. C.; Glarum, S.; Hebard, A. F.; Lyons, K.B.**

Raman studies of alkali-metal doped  $A_xC_{60}$  films ( $A = Na, K, Rb, \text{ and } Cs; x = 0, 3, \text{ and } 6$ )  
*Science*, **254**, 1625-7, 1992

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**Zhang, Zhe; Chen, Chia Chun; Lieber, Charles M.**

Tunneling spectroscopy of  $M_3C_{60}$  superconductors: the energy gap, strong coupling, and superconductivity  
*Science*, **254**, 1619-21, 1991

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**Yoo, C. S.; Nellis, W. J.**

Phase transformations in carbon fullerenes at high shock pressures  
*Science*, **254**, 1489-91, 1991

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**Suzuki, T.; Li, Q.; Khemani, K. C.; Wudl, F.; Almarsson, O.**

Systematic inflation of buckminsterfullerene  $C_{60}$ : synthesis of diphenylfulleroids  $C_{61}$  to  $C_{66}$   
*Science*, **254**, 1186-8, 1991

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**Krusic, P. J.; Wasserman, E.; Keizer, P. N.; Morton, J. R.; Preston, K. F.**

Radical reactions of  $C_{60}$

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Science, **254**, 1183-5, 1991

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**Varma, C. M.; Zaanen, J.; Raghavachari, K.**

Superconductivity in the fullerenes

Science, **254**, 989-92, 1991

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**Chakravarty, Sudip; Gelfand, Martin P.; Kivelson, Steven**

Electronic correlation effects and superconductivity in doped fullerenes

Science, **254**, 970-4, 1991

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**Iqbal, Zafar; Baughman, Ray H.; Ramakrishna, B. L.; Khare, Sandeep; Murthy, N. Sanjeeva;  
Bornemann, Hans J.; Morris, Donald E.**

Superconductivity at 45 K in rubidium/thallium codoped fullerene C<sub>60</sub> and C<sub>60</sub>/C<sub>70</sub> mixtures

Science, **254**, 826-9, 1991

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**Hedberg, Kenneth; Hedberg, Lise; Bethune, Donald S.; Brown, C. A.; Dorn, H. C.; Johnson, Robert D.;  
De Vries, M.**

Bond lengths in free molecules of buckminsterfullerene, C<sub>60</sub>, from gas-phase electron diffraction

Science, **254**, 410-12, 1991

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**Liu, Shengzhong; Lu, Ying Jie; Kappes, Manfred M.; Ibers, James A.**

The structure of the C<sub>60</sub> molecule: x-ray crystal structure determination of a twin at 110 K

Science, **254**, 408-10, 1991

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**Chen, Chia Chun; Kelty, Stephen P.; Lieber, Charles M.**

(Rb<sub>x</sub>K<sub>1-x</sub>)<sub>3</sub> C<sub>60</sub> superconductors: formation of a continuous series of solid solutions

Science, **253**, 886-8, 1991

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**Poirier, D. M.; Ohno, T. R.; Kroll, G. H.; Chen, Y.; Benning, P. J.; Weaver, J. H.; Chibante, L. P. F.;  
Smalley, R. E.**

Formation of fullerides and fullerene-based heterostructures

Science, **253**, 646-8, 1991

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**Li, Y. Z.; Chander, M.; Patrin, J. C.; Weaver, J. H.; Chibante, L. P. F.; Smalley, R. E.**

Order and disorder in C<sub>60</sub> and K<sub>x</sub>C<sub>60</sub> multilayers: direct imaging with scanning tunneling microscopy

Science, **253**, 429-33, 1991

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**Allemand, Pierre Marc; Khemani, Kishan C.; Koch, Andrew; Wudl, Fred; Holczer, Karoly; Donovan,  
Steven; Gruner, George; Thompson, Joe D.**

Organic molecular soft ferromagnetism in a fullerene C<sub>60</sub>

Science, **253**, 301-3, 1991

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**Snyder, Eric J.; Anderson, Mark S.; Tong, William M.; Williams, R. Stanley; Anz, Samir J.; Alvarez,  
Marcos M.; Rubin, Yves; Diederich, Francois N.; Whetten, Robert L.**

Atomic force microscope studies of fullerene films: highly stable C<sub>60</sub> fcc (311) free surfaces

Science, **253**, 171-3, 1991

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**Wertheim, G. K.; Rowe, J. E.; Buchanan, D. N. E.; Chaban, E. E.; Hebard, A. F.; Kortan, A. R.;  
Makhija, A. V.; Haddon, R. C.**

Photoemission spectra and electronic properties of K<sub>x</sub>C<sub>60</sub>

Science, **252**, 1419-21, 1991

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**Fischer, John E.; Heiney, Paul A.; McGhie, Andrew R.; Romanow, William J.; Denenstein, Arnold M.;  
McCauley, John P., Jr.; Smith, Amos B., III**

Compressibility of solid C<sub>60</sub>

Science, **252**, 1288-90, 1991

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**Fagan, Paul J.; Calabrese, Joseph C.; Malone, Brian**

The chemical nature of buckminsterfullerene (C<sub>60</sub>) and the characterization of a platinum derivative

Science, **252**, 1160-1, 1991

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**Diederich, Francois; Ettl, Roland; Rubin, Yves; Whetten, Robert L.; Beck, Rainer; Alvarez, Marcos; Anz, Samir; Sensharma, Dilip; Wudl, Fred; et al.**

The higher fullerenes: isolation and characterization of C<sub>76</sub>, C<sub>84</sub>, C<sub>90</sub>, C<sub>94</sub>, and C<sub>70</sub>O, an oxide of D<sub>5h</sub>-C<sub>70</sub>  
Science, **252**, 548-51, 1991

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**Hawkins, Joel M.; Meyer, Axel; Lewis, Timothy A.; Loren, Stefan; Hollander, Frederick J.**

Crystal structure of osmylated C<sub>60</sub>: confirmation of the soccer ball framework  
Science, **252**, 312-13, 1991

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**Kroto, Harold**

Space, stars, C<sub>60</sub>, and soot  
Science, **242**, 1139-45, 1988

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**Curl, Robert F.; Smalley, Richard E.**

Probing C<sub>60</sub>  
Science, **242**, 1017-22, 1988

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## 4. Konferencer

**George S. Hammond; Valerie J. Kuck (eds.)**

Fullerenes: synthesis, properties, and chemistry of large carbon clusters  
Washington, DC: American Chemical Society, 1992. ACS symposium series 481.

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**Jack M. Williams et al. (eds.)**

Organic superconductors (including fullerenes) : synthesis, structure, properties, and theory  
Englewood Cliffs, N.J.: Prentice Hall, 1992.  
Prentice Hall inorganic and organometallic chemistry series.

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