Available online at www.sciencedirect.com
ScienceDirect
C. R. Chimie 11 (2008) 1241–1253
Comptes Rendus Chimie
http://france.elsevier.com/direct/CRAS2C/

Account / Revue

Minireview: From molecular nanowires to molecular nanocables: Synthetic strategies and conducting properties

Frédéric Fages [a], Jennifer A. Wytko [b], Jean Weiss [b,*]

[a] *Centre Interdisciplinaire de Nanoscience de Marseille (CINaM), UPR 3118 CNRS, Aix Marseille Université, Campus de Luminy, Case 913, 13288 Marseille cedex 09, France*

[b] *Laboratoire de chimie des ligands à architecture contrôlée, Institut de chimie de Strasbourg, UMR 7177, CNRS/Université Louis Pasteur de Strasbourg BP1032, 4, rue Blaise-Pascal, 67070 Strasbourg cedex, France*

Received 17 December 2007; accepted after revision 9 April 2008
Available online 3 June 2008

Abstract

Whether nanosciences or real life, a straight line is usually the fastest way from point A to point B. If linearity is very frequent among inorganic scaffolds due to the crystalline character of the structures employed, the linearity in organic materials is significantly more difficult to control. An intermediate situation is found in the case of carbon nanotubes which can be grown in mats with a great deal of control over their orientation and size. The scope of this review is to provide, through selected examples, a general overview of the strategies available to obtain organic linear structures with interesting electronic properties. When available for the examples provided, physical data related to the electronic properties will be examined to outline the limitations expected in the case of organic nanowires and nanocables. Although these materials will hardly compete with inorganic solids, they still have a bright future complementary to the inorganic approach, and because of their production via soft chemical synthesis. ***To cite this article: F. Fages et al., C. R. Chimie 11 (2008).***

Résumé

Dans les nanosciences et nanotechnologies, il en est comme dans beaucoup de domaines de la vie macroscopique: la ligne droite est le chemin le plus court entre deux points. Si la linéarité est souvent de règle dans les assemblages inorganiques en raison du caractère cristallin des structures utilisées, la linéarité des matériaux organiques et beaucoup plus difficle à atteindre. Une situation intermédiaire est rencontrée dans les nanotubes de carbone, qui peuvent être obtenus en tapis avec un bon contrôle de leur organisation et de leur taille. L'objectif de cette revue est de donner, à travers une sélection d'exemples, une vue générale des stratégies disponibles pour atteindre des structures organiques linéaires avec des propriétés électroniques intéressantes. Si possible, pour les exemples fournis, les propriétés électroniques seront examinées afin de montrer les limitations inhérentes aux fils et câbles organiques. Si les matériaux organiques pourront difficilement rivaliser avec les composés inorganiques, ils offrent l'avantage de pouvoir leur être complémentaires, et peuvent être produits et intégrés dans des conditions douces. ***Pour citer cet article : F. Fages et al., C. R. Chimie 11 (2008).***

* Corresponding author.
E-mail address: jweiss@chimie.u-strasbg.fr (J. Weiss).

1631-0748/$ - see front matter © 2008 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.crci.2008.04.006

Keywords: Nanowires; Nanocables; Weak interactions; Supramolecular chemistry; Conduction; Conductivity

Mots-clés : Nanofils ; Nanocâbles ; Interactions faibles ; Chimie supramoléculaire ; Conduction ; Conductivité

1. Introduction

Over the last decade, the design of linear molecular architectures exhibiting electronic properties such as electronic or photonic conduction has been a constantly growing field of interest, aiming for new concepts and applications in molecular electronics. Illustrated by carefully selected examples, this non-exhaustive overview aims to emphasize the synthetic strengths, weaknesses, and complementary features of both the covalent and self-assembly approaches that lead to internally structured molecular wires, fibers, and cables, with respect to their electronic properties. Even though the use of single molecular wires to connect applied devices seems rather unrealistic, many uses for linear anisotropic molecular structures can be foreseen. However, the association of molecular wires, cables and fibers in devices with classical electronic components in transistorized devices requires the understanding and the mastering of the electronic properties and more generally the physical properties of linear, anisotropic, single molecules.

The scope of this update is deliberately limited to organic species incorporating iterative units, and will focus primarily on their preparation methods. Molecular wires, fibers, cables, and ropes will be distinguished in a way that recalls the stepwise structuration of collagene (single wire) into triple strands (fiber), hair (cable), and finally into ligaments (rope). Carbon nanotubes are also deliberately ignored because of their well-known properties, and commercial availability have already led to the development of research towards their integration in devices, grafting, and manipulation at the micro- and nanoscale.

In a wire that comprises an iterative monomer unit, no matter what the assembling method, the targeted properties are extrapolated on the basis of the physical properties of the monomer. The linear architecture is also defined by the chemical properties (bond angles, conjugation, steric constraints) of the monomers and their ability to connect with one another in a defined geometry, which, if linear, is far from the thermodynamically favored discrete reaction product. The controlled stepwise connection of monomer units into single molecular wires of low polydispersity will be examined first and followed by the polymer approach. The interest will then shift to non-covalent synthetic methods, after a brief recall of the weak intermolecular

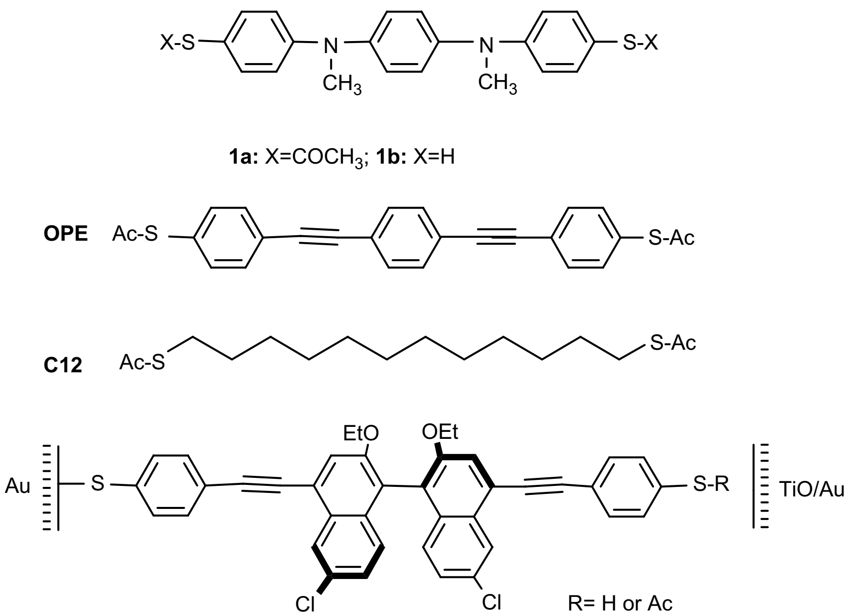

Fig. 1. Examples of rigid linear molecules introduced into nanoelectrodes or break-junctions. Top: **(1a)** oligo pyridine dithioacetate; **(1b)** oligo aniline-dithiol, OPE: oligo phenylethynyl dithioacetate, (C_{12} (used as a control)). Bottom: first optically active molecular wire.