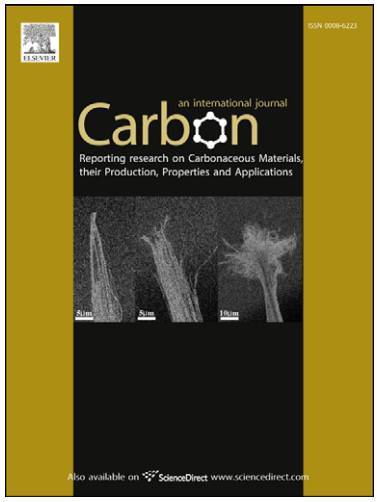

Editorial

Writing a Scientific Paper V – Language

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Writing a Scientific Paper V – Language

Many of you know that my year-round hobby is gardening. In the late winter I use a spade to dig and prepare the ground. After digging I use a rake to break up the soil to make it suitable for sowing seeds. In the spring I sow the seeds, and wait a few days to see young plants appearing. During the following weeks they grow into mature plants.

A scientist writing this might say: "In the late winter I employ a spade to cultivate and prepare the ground. After digging I utilize a rake to rupture the soil into microparticles, making it suitable for sowing small seeds. In the spring I distribute seeds in the prepared pulverised soil, and a few days later I see young plants, in situ, exhibiting signs of growth coming through the ground. In the following weeks there is an enhancement of dimensions and they become mature plants"

Scientists hardly ever "use" something! They either "utilize" or "employ" (how much do they pay?) or even "attribute". They love Latin phrases, even though they often have no idea what they mean. Nothing shows an increase, or grows; it "exhibits enhancements"! Experiments do not "show" anything, but they rather "demonstrate, exhibit or evidence"! Part of the reason is that some people are taught that it is bad to use the same word more than once, so they sit down with a thesaurus and go through all the words: "we used… then we employed… and utilized… and applied… etc"

I am, of course, exaggerating to make a point. When I was very young I was taught never to use a long, complex word or phrase when a simple one would do. This is as true today as it always was, especially when communicating with people of many different languages, which is what we are doing in a scientific paper. But today's scientists appear to want to avoid simple language. "This is a complex subject and it needs complex language to describe it." How pretentious!

While the worldwide language of science is English, most readers and writers of scientific papers are not native English-speakers. It is therefore important that we keep our language as simple as possible, without destroying the meaning, and that we make sure our language gives a clear and unambiguous message. This is especially true for titles and abstracts that may determine whether a potential reader will pay to download a manuscript from the journal website.

The following are examples of some of the most common difficulties and errors that I have encountered in recent years. I trust they will be useful.

Finding the correct word.

This is a major problem faced by people whose native language is not English. During my years as Editor my vocabulary has increased because of words used in papers that I do not understand. A recent paper on the dispersion of carbon nanotubes in a polymer described them as "boscage-like". Where did the author find this word? I found from the dictionary that a boscage is a "mass of trees or shrubs", something we might call a "thicket". The author was trying to say that the nanotubes were assembled into tangled masses.

Sometimes I come across words that make no sense. A carbon material was once described as "caducous", a botanical term that means that something is "easily shed at an

early stage". Months later I am still puzzled by how the author found the word and what he was trying to convey by using the term. I shall probably never know what an author meant when he described his carbon as "homogametic".

Perhaps the spell-check system is occasionally to blame. Earlier I was checking a manuscript that contained the word "chirality". The spell-check suggested that I change it to "chairlady"!

I can understand the difficulty an author has when searching a dictionary for an English word to translate one from his native language, and being presented with a range of choices. My advice is to pick the one that you know, and if none fit this criterion, look for uses of the word and their context before using it. Describing porosity as "helminth-like" would certainly have been changed to "wormhole-like" if the author had checked other uses of helminth and its possible alternatives! Another tangle of nanotubes was described as a "clew". I had to go to the dictionary to find the meaning. I will leave you to do the same, but I doubt that it will help!

Long adjectival phrases.

Why does normal speech often vanish when writing the title for a paper? I might be describing "The use of microporous carbon spheres doped with carbon nanotubes for the manufacture of high-performance supercapacitors with low series resistance". But the title becomes "High-Performance carbon nanotube-implanted mesoporous carbon spheres for supercapacitors with low series resistance". The title provided by the authors is certainly a little shorter, but is ambiguous. What is "high-performance"? The carbon nanotubes, or the carbon spheres, or the supercapacitors? The title begins with a long adjectival phrase "High-Performance carbon nanotube-implanted mesoporous" that should describe the carbon spheres. But "high-performance" describes the supercapacitors. If you were verbally explaining what you had done to a fellow scientist over a cup of coffee you certainly would not use the expression in the submitted title.

Another paper title refers to "a gelatin dispersed multiwalled carbon nanotube composite film". A hyphen between "gelatin" and "dispersed" makes things clearer, but surely "a composite film of multiwall carbon nanotubes dispersed in gelatin" is even better.

Yet another recent example of a poor title is "Vertically-aligned carbon nanotube arrays embedded bismuth telluride based thermoelectric composites". Can you figure out what it means? I doubt it!

I cannot explain this trend of wanting to abandon normal speech and combine everything into one long adjective. "Soft-template synthesized ordered mesoporous carbon counter electrodes…." Is surely more understandable as "Ordered mesoporous carbon counter electrodes synthesized using a soft template….". Avoid long adjectival phrases. They tend to be a type of shorthand that can lead to ambiguity and they can always be eliminated, although the result is usually longer.

Verbs that end with "-ing" and "-ed" (participles).

Here again we have a problem with an adjectival phrase, and it must be one of the most difficult problems faced by a non-native English speaker. A simple example should

pinpoint the problem. In the phrase "boron containing carbon" the word "containing" is what we call the "present participle" of the verb "contain". The subject is boron, and the phrase indicates that the boron contains carbon. The implication is that most of the material is boron, and the carbon is a minor component, i.e. an impurity. If I add a hyphen "boron-containing carbon", the two words are joined to make the adjectival phrase "boron-containing". The subject is now carbon and the adjectival phrase describes the carbon, i.e. it contains boron. The situation is now reversed; we have a material that is mostly carbon with boron being the minor component. The solution to the dilemma is simple. It is always much clearer to say "I have some carbon that contains boron (impurity)", or vice versa.

Changing the "-ing" to "-ed", something often done by non-native English speakers, can completely change the meaning and also cause confusion. The meaning of "I have some boron-contained carbon" may not be immediately clear, but the most likely interpretation is that I have some carbon that is contained by boron, i.e. encapsulated by a layer of boron. This is no longer a matter of an impurity. To say that "I have some carbon with a boron coating", or "…. carbon contained in a boron capsule" may be a little longer, but is clear and unambiguous.

A recent manuscript says "The figure shows X-ray diffraction peaks originated from the nanotubes". The statement tells the reader that the figure *proves (shows)* that the peaks originated from the nanotubes, but this is not what the author meant. What was meant was that we know the peaks in the figure come from the nanotubes and the figure simply shows them. The figure does not prove that the peaks came from the nanotubes. There are two possible ways to say this correctly, either "The figure shows X-ray diffraction peaks originating from the nanotubes" or "……shows X-ray diffraction peaks that originated from the nanotubes". Changing –ed to –ing makes a subtle difference.

The same difficulty commonly arises in scientific papers with verbs such as encapsulate, surround, insulate, oxidize. In many cases it may help to think of –ing as being active and –ed as being passive, but this does not apply to all cases. For example, "The material is oxidizing." means that the material is in the process of being converted to an oxide. When the process is complete we say that the material is oxidized (passive). But "The material is oxidizing the substrate" means that the material is causing the oxidation (active) of the substrate.

If the above discussion is confusing you (active), you are clearly confused!

Again, it is easy to eliminate ambiguity, but the result is usually longer. Never sacrifice clarity for the sake of brevity!

"Via" and "in situ"

Why do scientists who have probably never learned Latin love these expressions? Most times I see them, their use is either inappropriate, unnecessary, or wrong.

"Via" is the Latin word for "road". The dictionary defines it as "traveling through (a place) en route to a destination". It implies an intermediate state or stage. From London I can travel to Tokyo via Frankfurt, i.e. I make a stopover in Frankfurt. It is correct to say that "the carbon was produced by chemical vapor deposition", but most papers I receive say "the carbon was produced via chemical vapor deposition"! The English word "by" is

accurate and shorter! A longer alternative is to say "the carbon was produced using chemical vapor deposition". Most uses of "via" in scientific papers are wrong!

The correct use of "via" is discussed in a chapter entitled "The Search for the Missing Ablative" in *The Chemist's English* by Robert Schoenfeld (Wiley-VCH, 1989). He points out that you can "proceed from an alcohol to an acid via an aldehyde. But don't try to determine the structure via n.m.r. If you do, the reviewer may return your manuscript to you for correction, via the editor." The book is worth reading.

"In situ" is the Latin for "in a place" or "in the place" (Latin lacks articles). Everything happens in a place and in many cases the expression can be deleted without loss or change of meaning. In many cases the words "*in situ*" can emphasise that the process takes place where the material is used or examined. "*In situ* TEM examination of the fracture of carbon nanotubes" means that the fracture took place in the TEM while the nanotubes were being examined. The nanotubes were not fractured using equipment on a laboratory bench and then transferred to the TEM for examination. However, the "*in situ* infiltration of carbon brakes" indicates that the brakes are infiltrated while on the vehicle where they are to be used, which to my knowledge is never true.

The Latin abbreviations i.e. (*id est* – that is) and e.g. (*exempli gratia* – for example) are of common use in English, but there really is no need to use other Latin expressions. Occasionally I see papers that say "*vide supra*", but it is just as easy to say "see above" and one does not need to know Latin to understand it! The same is true for *"vide infra"*, meaning "see below".

"Respectively."

The correct use of this word is to link two or more lists in the order in which items appear in them. "Samples A, B and C were heat-treated at 250, 400 and 600°C respectively", means that sample A was heated at 250°C, sample B at 400°C and sample C at 600°C. Many people automatically add the word respectively after a list, as in the following: "Samples were heated at 250, 400 and 600°C respectively". The use of the word here is wrong and it must be deleted.

"Synthesis" and "synthetic".

These two words are often confused. *Synthetic* is **always** an adjective and means artificial. A synthetic fiber is man-made, e.g. a polyacrylonitrile (PAN) fiber. Synthesis is a process, a noun. The synthesis of a carbon fiber may use a PAN fiber precursor. However, in English we often use the noun in an adjectival role, so we can talk about "the synthesis conditions". We do *not* say "synthetic conditions". In the same way we use fiber as an adjective in "carbon fiber synthesis" or "carbon fiber properties". [Note that we never use the plural when using a noun as an adjective, so "carbon fibers properties" is wrong, while "properties of carbon fibers" is correct.]

A recent manuscript, which had been edited by an English language editing service, talked of the "synthetic temperature". I told the authors that it should be "synthesis temperature", and because it contained many other language errors, they returned it to the

editing service. The paper was resubmitted and now read "synthesised temperature"! How can you synthesise a temperature? It is a shame that some language editing services do not understand the different meanings of these words.

"Structure" and "Morphology".

In my lectures introducing materials science I always pointed out that the subject was the study of the relationships between the structure, properties and processing of materials. There are different structure levels: electronic, atomic, crystal, micro- and macro-. Morphology is related to the macrostructure and usually defined as the shape (form) and size of a material (some people include texture). More and more papers are using the word as a synonym for structure, which is wrong. For example, you do not use X-ray diffraction to determine morphology! A material may have a porous structure, not a porous morphology. This may be another example of where a longer word is used because it appears to be more important

"Composite" and "Hybrid".

I cannot say that there is universal agreement on a distinction between these two terms, but I think the following is helpful, and I try to ensure that papers in CARBON use this distinction. A composite material is one with a matrix and a filler, and is conventionally designated filler/matrix, not the reverse, and not filler-matrix. The filler is often added to improve a property of the matrix (e.g. adding carbon nanotubes to improve the thermal conductivity of a polymer) but sometimes the major function of the matrix is to hold the filler in place (e.g. the fibers in carbon/carbon composites). A hybrid material may consist of two different materials that are joined to take advantage of the properties of both. (A hybrid automobile usually takes advance of a gasoline-powered internal combustion engine and a battery-powered electric motor). A "graphene sheet-manganese dioxide hybrid" consists of graphene sheets with attached MnO_2 particles, and may find applications in supercapacitors. There is no matrix, and the use of a hyphen rather than "/" makes it clear that this is so.

Tautology.

"The saying of the same thing twice in different words." The most common example of this is in figure captions where something is described as a "schematic illustration". An illustration is automatically schematic and the two words mean essentially the same. You would never say that you "drive a car automobile", and in the same way "schematic illustration" is redundant. One of the two words is sufficient. In carbon science we have illustrations of tautology within one word. In his landmark paper on carbon nanotubes, before the term "nanotube" was accepted, Iijima referred to his material as "microtubules", something I call a "double-diminutive". Both the "micro-" prefix and the "–ule" suffix indicate something small. The term is no longer used. The same occurs today with "nanoplatelet". A nanoplate means a plate of nanometer dimensions and the suffix "–let" is unnecessary because it merely denotes something small.

Collective (mass) nouns.

Purists will say that mass nouns and collective nouns are quite different, but it is well to avoid the distinction here. The point to be made is that there are some nouns that are rarely used in the plural in English. Some of the most common in scientific writing are "work", "research", "information", "literature", and "equipment". Many papers begin with a statement similar to the following: "Previous works on carbon nanotubes have…..", or "Previous researches…" There is no ambiguity here, but a native speaker would either say "Previous work (research) on…." Or "Previous studies (papers) on….". Work and research are used as collective (mass) nouns. This morning I received a paper that started "Recently, lots of researches have been…..". The author should say "Recently, there has been much research….." In the same way we would say "The equipment used….." and not "The equipments used…" where "equipment" is a collective noun that includes SEM, TEM, NMR, XRD, etc.

"Exfoliation."

This word is finding increased misuse. The correct meaning is to "be shed from a surface in scales or layers". I can therefore have exfoliated graphite, and I can have an exfoliation treatment for my skin. If I speak of exfoliating multiwalled carbon nanotubes, it means that the many graphene layers (a tautology?) or walls of the nanotubes are somehow separated and some parts of the layers are shed. This is **not** the same as separating and untangling the nanotubes from each other. To describe separation and unraveling of the nanotubes as "exfoliation" is wrong.

"Facile."

This word is currently "in vogue" (like "enhance"). One person uses the word and other people think it is a "good idea"! Nothing is "easy" or "simple' any more. Everything is "facile"! There is an implication in modern English for facile to indicate a degree of uncertainty. A facile argument or explanation is one that is so simple that it is difficult to believe. It is not to be trusted. So much better to say "easy" – also shorter!

"Nano-"

The prefix "nano-" should indicate that the item has a nanometer dimension. In "nano-graphene", what is the "nano" intended to indicate? If "nano" refers to the thickness, it is unnecessary (another tautology!) because a graphene automatically has a thickness of nanometer dimensions. If it refers to the lateral dimension (width) it would appear that the particle is too small to handle and control. "Large graphene nanosheets" is an absurdity! Nanocomposite, nanofluid, etc. are used widely but are also etymologically incorrect. (See Editorial in CARBON 42/12.) Scientists should appreciate that you can never justify something on the basis of earlier wrong misuse, however common. However the words are being used so frequently that I believe I am "losing the battle". I am sure that my successor as Editor will allow their use.

"Conclusion", "Conclusions" and "Summary"

The "Conclusion" [definite article] of something is the ending. A "Conclusion" [indefinite article] is a judgment or decision reached by reasoning - a deduction. If the paper ends with a concluding statement the section should be entitled "Conclusion" or "Summary". A "Conclusions" section should contain a list of things (plural - more than one) that have been learned as a result of the experimental work described in the paper. It is certainly wrong to have a title "Conclusions" and start the section with "In summary .." or "In conclusion .." This also applies if either of the other two headings is used. In most papers the final section should be headed either "Summary" or "Conclusion" because rarely do authors list conclusions.

"New", "Novel", "For the first time", "Successfully"

These words are almost always unnecessary in a scientific paper. Most (all?) research is concerned with discovering new things. That's what research is about. If you have prepared a material, it is obvious that you have been successful in doing so! In "we have successfully prepared…." the word "successfully" is unnecessary. Rarely do people write a paper about their failures, and papers that report a repetition of work done 10 years ago are almost certain to end up in the "Reject" file!

"Different" and "Varying"

There is a subtle but important difference between these two words. "Different" implies more than one. I can treat three different samples at five different temperatures, giving me fifteen samples for examination. "Varying" can apply to one item. A varying temperature means that the temperature changes, i.e. it is not fixed. Authors often say that their samples were treated at varying temperatures, when they mean different temperatures.

"Template" and "Substrate"

Here are two more words that are often confused. A substrate (Latin *sub* – under) is usually a material that provides the surface on which something is deposited, i.e. it is under the deposit. A template is a material used as a pattern. A zeolite may be used at a template for the production of a porous carbon. The carbon is deposited on the zeolite substrate that is then removed, by e.g. acid treatment. The zeolite acts as a substrate for the carbon deposition and is a template for the resulting carbon material, which is effectively the negative of the zeolite.

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