Syntactic features of scientific articles on materials science

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Abstract. The paper gives an outline of the syntactic features of the texts. The purpose of the research is to define grammatical forms and syntactic structures observed in scientific articles from the journal “Advanced Engineering Materials” (2018). The article also presents the analysis of verbal constructions and phrases in scientific articles on materials science. The tense forms used in the articles under investigation are also considered. The analysis has revealed the gerund to be the most frequently used verbal form. The main functions of the gerund in the articles are subject and adverbial modifier. The infinitives are not so frequent as gerunds and are used in the function of adverbial modifier of purpose mostly. The participles in the articles fulfill the function of an attribute either in pre- or post-position. The other syntactic features include passive voice forms of present simple, past simple and present perfect simple tenses.

1. Introduction

Language used in science describes and interprets the world, projecting the objective character of scientific knowledge. Scientific and technical communication can be defined as a process of gathering, organizing, presenting and refining information. Persuasion is also a part of such communication which appeals to objectivity to convince an audience. It is also a process inevitably shaped by its contexts, and which is improved when it recognizes its contexts.

Effective scientific and technical communication is an integral part of all professions and fields of study in an industrialized society [1]. The qualities attributed to effective scientific and technical communication, such as accuracy, clarity, precision and thoroughness, correspond to the understanding of what makes science and technology work effectively.

The main purpose of any scientific writing is undoubtedly to acquaint the public with researcher’ findings. Scientific publications serve as a ground for academic communication and exchange of opinions [2]. Any publication should therefore cover the background, the procedure and results and meaning of the research. Scientific words differ from ordinary and literary words since they do not accumulate emotional associations and implications. Scientific language is supposed to be more direct, free from alternative, and much less artistic than literary language. The language of science is characterized by impersonal style [3]. It is generally considered that scientific or technical texts are quite neutral, as they contain a lot of terms and do not have many stylistic expressive features. However technical and scientific texts possess their own peculiarities despite the factual and objective information they represent.

The main distinguishing feature between the scientific and literal text is that any scientific text do not create any aesthetic effect. It purely states the facts, supporting and proving them with experimental data. So the words in scientific writing do not convey any connotative or symbolic meaning, it is primarily terms and words in their direct meaning.

While analyzing scientific texts, one should pay attention to the general style features of scientific writing, such as clarity, precision and logical sequence of ideas and viewpoints presented. Integrity is the other essential characteristic of any scientific article [4]. Each thought should be logically expressed and supported by evidence. The logical structure of writing allows the reader to follow and grasp the text with ease.
The scientific writing has its own peculiarities. Syntactic features of scientific texts have been studied and defined. Being aware of these features helps scientists write their paper correctly and to convey the results of the research. It is also of great importance for non-speakers of English, because foreign scientists should be able to understand the peculiarities of the English syntax in scientific articles to gain the main idea and get to know the research itself, its results and meaning for the scientific field.

Theoretical discussions of the grammatical features of academic writing can be found in works by scholars from systemic functional linguistics [5]. Its approach to academic language regards nominalization as a pivotal linguistic device that distinguishes formal technical writing from everyday spoken interaction and as a major source of syntactic complexity in writing. Nominalization, i.e. verbs and adjectives converted to nouns through derivation, is a powerful device for packing and integrating information. Nominals substitute the clauses where the same thing could be expressed. As for grammatical constructions and forms used in technical writing, the most common are the Passive Voice, the Participle, the Infinitive, the Gerund. Scientific and technical writing is also characterized by the abundance of terms and specialized terminology [6, 7]. Sentence structures are presented by complex or compound-complex sentences with two or more subordinate clauses joined synthetically or asyndetically.

2. Non-finite verb forms
Non-finite verb forms are considered to possess the characteristics of a verb, as well as other parts of speech. So, the Participle has a double nature of a verb and an adjective; the Gerund and the Infinitive combine the characteristics of a verb with those of a noun. Verbs can only be part of the predicate and they must always be in connection with the finite form of the verb. The verbs can form predicative constructions, consisting of a nominal expressed by noun or pronoun and a verbal expressed by a participle, a gerund or an infinitive [8]. In such way the verbal is connected with the nominal element by means of predication.

In contrast with the finite forms, the tense distinctions of the verbals are relative showing if the action is simultaneous with the action expressed by the finite verb or prior to it.

Verbs can fulfill different syntactic functions. The Participle can be an attribute, adverbial modifier, a predicative, part of Complex Object. The Gerund can function in the sentence as a subject, a predicative, an object, an attribute, an adverbial modifier, be a part of a compound verbal predicate and of a complex object. The Infinitive can serve as a subject, predicative, an object or as an adverbial modifier. Moreover, infinitives, participles, gerunds and verbless clauses represent four general types of nonfinite subordinate clauses.

2.1 Participle and Gerund
We analyzed articles from the scientific journal “Advanced Engineering Materials”. The following examples from the articles show how non-finite verb forms are used and what their syntactic functions in the sentence are. First, we consider the syntactic functions of the participle:

While the effective dielectric permittivity being improved by adding the ceramic nanofillers into polymer matrix, the electric field may concentrate near the nanofiller–matrix interfaces, and make these regions weak points in the breakdown process.

Absolute Participle construction is a secondary clause that modifies the whole meaning of the main clause. In the sentence a Nominative Absolute Participial construction functions as an adverbial modifier of time. In the construction the participle being improved stands in predicate relation to a noun permittivity in the common case.

The examples given below show The Past Participle serving as an attribute:

Two special microstructures filled with BaTiO3 nanofibers and nanoparticles at the same volume fraction of 10% are considered.

Based on the switching mechanism, commonly studied resistive switching devices can be generally divided into two groups: devices based on the migration and redistribution of metal cations such as
Ag or Cu ions, and devices based on the migration of anions such as oxygen ions, leading to redistribution of oxygen vacancies (VOs).

In the sentence there are three forms of Participles II and one form of Participle I. All the Past Participles, the first detached attribute in pre-position and the others in post-position, fulfill the function of attribute. The Present Participle functions as an adverbial modifier of result. Moreover, parallel constructions that modify the subject devices aim to point out two different devices operating on different principles.

By directly changing the properties of the storage material itself, the device also directly modulates the signals propagating through it, thus allowing logic functions to be performed at the same physical locations as the memory element, leading to significant speed and energy benefits.

The example presents a variety of verbal forms with -ing ending. So it is quite difficult to define each form at first sight. The first verbal with preposition by directly changing is a gerund in the function of adverbial modifier of manner. The Participle I propagating as an adverbial modifier of manner modifies the noun in post-position. The construction “participle + passive infinitive” with conjunctive adverb thus functions as adverbial modifier of result. Such clauses are very common in formal written English. The participle I leading is an adverbial modifier of result. The abundance of participle clauses make the simple sentence more extended without being a complex one.

It should be noted that a prepositional phrase that includes - by + a gerund as an adverbial modifier of manner is quite common in scientific articles. It makes it easier for the authors to show the methods of analysis or to explain the chain of experimental studies. More examples of gerund in this function are given below:

It is also noted that hollow structuring of the electrode materials has been proved as a promising avenue to boost the electrochemical performance by effectively alleviating the stress-induced structural variation during long-term electrochemical reactions.

The shell number and composition can be precisely controlled by simply tuning the amount of VOT used in the reaction systems, thus allowing the preparation of triple-shelled Co3O4@Co3V2O8 nanoboxes.

The gerund functioning as a subject is also frequently used in scientific articles. Therefore, developing highly efficient and robust HER electrocatalysts to lower the overpotentials in alkaline media is highly desirable for electrochemical water splitting.

Being transparent for light-emitting diodes (LEDs) significantly expands their applications by displaying visual information on objects without affecting their original appearance and functionality.

In the sentences the Gerunds at the beginning are subjects, the second prepositional form is an adverbial modifier of manner and the Gerund after preposition without is an adverbial modifier of condition. The next example also illustrates the subject expressed by the gerund form.

2.2 Infinitive

Infinitives in the sentence can also fulfill different syntactical functions. The examples given below illustrates the usage of the infinitive phrases in the function of adverbial modifier of purpose:

To reveal the spatial distribution of different elements in the T-Co3O4@Co3V2O8 NBs, elemental mapping analysis is carried out on a representative T-Co3O4@Co3V2O8 nanobox under scanning transmission electron microscopy (STEM) mode.

To obtain further insight into the formation process of multishelled Co3O4@Co3V2O8 nanoboxes, syntheses with different VOT concentrations are carried out.

Afterward, the assynthesized particles are annealed in air to obtain a variety of hollow structures.

To investigate the protective role of the ETLA_x during the top electrode deposition, we exposed the ETLA_x-coated QD films to Ar plasma (30 W, 13 Pa).

... have been proposed and explored for years in order to improve the energy density._
In aim to regulate these factors for better catalytic performance, surface reorganization was regarded as a promising way to modify the electrocatalysts.

Attributive function of the infinitive can also be observed in scientific papers but its cases are not so common. The following sentences illustrate the function of infinitive as an attribute.

When coupling with vanadium element to form cobalt vanadates (such as Co3V2O8), the electrochemical performance of these ternary TMOs can be largely improved.

Another effort to improve the EL performance is structural engineering of QDs.

3. Other grammatical verb forms

Along with non-finite verb forms, finite verb forms in different grammatical categories are widely used by scientists and researchers. As for The Passive Voice forms, they allow to create an objective tone in scientific papers. The passive voice is also necessary when the doer of the action (the subject) is less important than the action itself or the result of the action. Therefore, the Passive voice constructions are involved in creating an impersonal tone in scientific discourse. This grammatical verb form seems to reduce the involvement of the researcher who actually carried out different actions: formulating the assumptions, collecting the data, conducting experiments, providing interpretation of the findings, drawing conclusions [9, 10]. Recent studies on passive constructions in scientific writing show that many researchers argue the prevailing role f passive forms over active forms. The passive forms seem to have lost their significance for scientific discourse in written form. Nowadays there is a tendency among linguists and experts to consider active verb forms more appropriate in scientific writing.

The analysis has revealed the simple and perfect passive forms used in scientific articles, such as present simple passive and present perfect simple passive forms. Passives are typically used in main clauses if the sentence is a simple one. Rarely the passive forms are observed in relative clauses. The present passive forms are widely used for the description of the procedures:

Then, this phase-field model is employed to perform a high throughput calculation.

Finally, an artificial sandwich microstructure is designed and optimized.

Present perfect simple passive forms are found to referring to previous studies, experiments or results achieved in the given area of study. These forms are usually modified by an adverb, e.g. have been extensively studied, have also been performed, has been extensively carried out, have been successfully demonstrated. These forms are observed in Introduction section of the paper.

Past Simple Active or Passive verb forms are rarely observed due to the fact that current research should reflect the actual and present state of events and the latest findings in given field of science. Past simple forms are used mainly when researchers want to highlight previous experimental results or about certain last studies in their field.

To examine the effect of the ETLA x on the carrier dynamics, the TRPL spectra of QDs in Tr-QLEDs were measured under applied biases.

CoP nanowire arrays grown on carbon cloth (CoP NWs/CC) were synthesized by the phosphorization of CoOHF nanowire arrays.

Therefore, the above results clearly suggest that the CoP nanowires supported on carbon clothes were successfully synthesized.

We prepared a series of alloyed core/shell CdSe/ZnS QDs by growing ZnS shells of different thicknesses.

4. Sentence types

In scientific writing different sentence types can be observed. If we look at the above-mentioned examples with non-finite verb forms in the sentences, we can notice that most of the sentences are simple ones, expanded by phrases or constructions. A simple sentence can be very short, consisting of a noun for the subject and a verb for the predicate, but in scientific writing it can have further extensions at the sentence initial, middle, and final positions. Simple sentences can be expanded by additional phrasal segments from the beginning, middle, and at the end by such phrases like noun
phrases, adjective phrases, adverb phrases, verb phrases, infinitive phrases, gerundive phrases, participle phrases, participial phrases, and appositive phrases [11]. The examples with nonfinite clauses show sentences extended from the beginning or from the end.

To verify the function of surface reorganization by oxygen plasma engraving, all the pristine and treated CoP NWs/CC are compared in alkaline HER as electrocatalysts.

To further understand the reason for outstanding HER activity of CoP NWs 40s/CC after surface reorganization, the systematic characterizations were performed to show the homojunction.

In such a way, sentences are expanded without any clauses, dependent or independent. The main independent clause usually occupies the middle part of the whole sentence, extended by participle, infinitive or gerund clauses. However, complex and compound sentence types remain a distinctive feature of the scientific papers.

Complex sentences with subordinate clauses in scientific writing are connected synetically, with subordinate conjunctions. They usually contain two clauses. The dependent clause is essential clause in scientific papers.

Complex sentences with subordinate clauses are mainly used for the description of the experiment. In the abovementioned example complex sentences illustrate the influence of the electric field on the material under different parameters. The adverbial clauses with subordinate conjunctions when and until express cause/effect relations between the clauses and denote the outcomes of the conducted experiment. The attributive relative clauses introduced by the relative pronoun which are primarily Object relative clauses in the articles:

Taking CoP nanowire arrays grown on carbon cloth (denoted as CoP NWs/CC) as an example, the homostructure CoOx/CoP interface was precisely-controlled constructed by the adjustment of plasma treatment time, which is visually verified by the X-ray absorption fine structure (XAFS).

The current recorded with the surface reorganization CoP catalyst (CoP NWs 40s/CC) shows an outstanding HER performance for −0.146 V at 100 mA cm$^{-2}$ versus the reversible hydrogen electrode which possesses the outstanding alkaline HER performance in reported electrocatalysts.

The vertical phase segregation maximizes the morphological continuity of semiconductor component, which provides the effective pathways for charge transport.

Compound sentences in the articles under investigation are often made up of two clauses.

As a result, the device lifetime with ETLa_0 is very short, less than 1 h at 1500 cd m$^{-2}$, and the device lifetime variation between devices is large.

A unique solid-state battery system was designed and its working mechanism is illustrated in Scheme 1.

The most frequently used coordinating conjunctions are and and but, whereas the subordinating conjunctions are more varied and they are mainly used to define sequence and cause/effect relations between the sentences. The examples of the conjunctions from the articles are when, after, before, until, if, while.

The sentence types mentioned above are appeared to prove the syntactic complexity of scientific articles. In other words hypotaxis along with parataxis are indispensable features of any research paper.

5. Conclusion
Scientists and researchers make use of a variety of syntactic structures in differing proportions. Syntax of research papers are characterized by a number of peculiarities that have been studied. The purpose of the article has been to reveal syntactic features in the material science articles. The use of non-finite verb forms, The Passive forms, the impersonal character of writing, different sentence types have been observed as the essential traits of scientific articles. The analysis of technical articles allows us to define the syntactic functions of the verbals. The Participle is used primarily as an attribute in pre-position or post-position. The Gerund functions as an adverbial modifier of manner and as a subject. The Infinitive is observed, expressing an adverbial modifier of purpose. It also used to modify a proceeding noun as an attribute. The passive verb forms are mainly observed in the past simple, present simple and present perfect tenses. Although most linguists consider active verb forms more As for sentence types, the most common are simple sentences extended by infinitive phrases, gerundive phrases, participle phrases. Complex sentences are found to be preferable for describing experimental procedure or for showing the cause/effect relations of different phenomena types of machinery employed or different devices. It also indicates the behavior of a tested object or phenomenon under different conditions. The above-mentioned features tend to cluster together as characteristic of scientific writing. The result of the current study will be immensely useful for the novice researchers of science, because it can help them to write their research papers with grammatical accuracy and organize their findings in a systematic manner. Moreover, being aware of syntactic features in scientific articles it is of great importance to scientists who are not native English speakers, as it help them to get the main point of the article and to understand the text more clearly.

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