

Characterization of the Polymeric State of Matter

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Abstract

The asymptotics of a number of limit states of polymers and the transformation of molecular orbitals during their polymerization are analyzed. It is shown that it is these transformed molecular bonds, and not van der Waals, that provide both the linkage of different polymolecules and the branching of each polymolecule separately. At the same time, the fundamental difference between polymers formed at the elementary level due to endothermic chemical reactions and crystals formed due to exothermic reactions is shown. The revealed patterns of polymerization make it possible to use it to create new effective media, such as high-temperature superconductors and high-performance thermoelectrics and electrolytes. And also - and to create Nano-elements for electronics and optics with a given modulation of the energy potential. In addition, such polymers, in principle, can be used as material from which organs in need of transplantation will be created.

Keywords: Electron orbital, polymolecule, frontier orbital, endothermic reactions, van der Waals forces, scale effects, effective medium, Nano element.

Introduction

As in many sections of modern Science, which has degraded along with the Society, there are contradictions even in the DEFINITIONS of polymers. And to these “definitions”, which, again, are used only for decoration of articles, dissertations and books, a bunch of abstruse, but often in no way related to them, and a huge pile of reports of factory laboratories on research of properties of various polymers, but carried out, as they say, “without a king in the head”, are attached purely formally. Whereas the Truth Science corresponds to EVISTICITY, i.e. PREVENTION on the basis of Fundamental Laws, but not on the basis of private, local laws. So even our work on polymers (which, if I promised, I did) will start from the BEGINNING, from untangling Logical Tangling and finding Intertwining of those Logics which are built on INVARIANTS (Haskell B, 1963).

In general, from the presence of the INVARIANTS themselves in this state of matter, under the traditional definition of which ideal crystals also fall (as a single molecule), BUT which does not have translational INVARIANCE. BUT, at the same time, it is not an ideal amorphous body either.

The process of crystal formation is accompanied by energy release, while the process of polymer formation is accompanied by energy consumption. That is, the difference between their “growth” at the fundamental, ELEMENTARY level - at the

level of the underlying exothermic or endothermic chemical reactions.

And the final state of polymers looks like a rolled up felt. BUT it looks more like what determines the very PROCESS of polymerization - on the sprouted roots of plants, although more precisely on the sprouted mycelium, only gobbled up all the soil. The state, the Science about which is based on the ancient idea introduced by Pauling about flat electron orbitals (Ordin & Sharrupin, 1998; Ordin, 2002). But which, these flat orbitals, Pauling himself tried to correct into “curves”. But who was pushed aside so as not to interfere with dissertations and “scientific” titles (Ordin, 2008; Ordin, (n.d)).

So it turns out that mankind, not only in the production of polymers, but also in their creation, wastes enormous effort, eating up the resources of the planet (actually terraforming it for bourgeois needs). The tone of this mismanagement bordering on madness is, of course, set by businessmen and “economists”. But also Science, following them in the fairway, is now developing extremely inefficiently - by the method of ants or blind kittens, which are drowned in a bucket. As Professor V.N. Bogomolov said back in 1975: modern scientists are like ants in a bucket, scurrying up and down until one of the ants reaches the edge of the bucket. That’s when all the others

will follow his trail out of the bucket. Only the now deceased professor did not suppose that in our time even Nobel prizes are given for complete bluffs, and the ideas of the coryphaei of science are covered by a “cultural layer” of ignorant articles and dissertations. So the benchmarks have been lost. To restore them it is necessary to return to the Fundamental Laws.

In the thermostatic approximation, the Principle of Maximum Entropy is taken into account, and the Harmony of inanimate Nature is determined only by the Law of Minimum Potential Energy, which is useful to use to estimate “instantaneous states of polymerization, but the essential, temporal moment will be missed (Fig.1).



Figure 1: “Frozen” Harmony of Inanimate Nature

For HARMONY and inanimate Nature, but already taking into account the flow of TIME, the Law of Conservation of Total Energy predominates (Gyarmati, 1974). The same Law manifests itself in a “frozen” form not only in the given photos (Fig. 1), but also in formed incommensurate crystals that “froze” their prehistory (Vakhrushev & Ordin, 2003 ; Bourgeois et al., 2004 ; Ordin, 2011) (Fig. 1e).

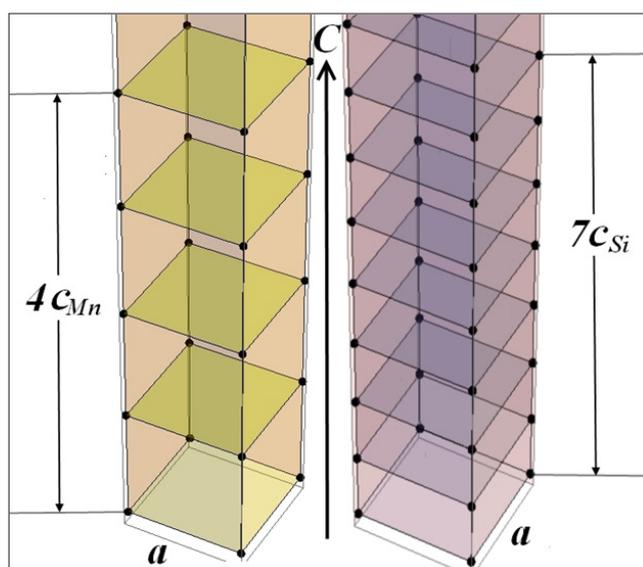


Figure 1e: “Frozen” sub lattices of a one-dimensionally incommensurate crystal of the Highest Manganese Silicide.

And for polymers this “freezing” is crucial - it is determined by artificial stopping or going to saturation of molecule growth. And, as an ELEMENTARY consequence of the above: for polymers as well, it is necessary to take into account not only the traditionally used electronic orbitals, but also their transformation, in particular those which have been repeatedly experimentally observed on their numerous IR transmission spectra, but which have been neglected, writing off all interaction between chains to Van der Waals.

One last, methodological remark. When I was young, I, like everyone else, started my research with literature data. But then I was faced with the fact that the data (as it seems generally accepted) can be inaccurate, and they were obtained on samples far from perfect. As in the same article on boron nitride (Geick et al., 1966), with which I began his study as an extremely anisotropic, according to the volumes of theorists, model crystal (Bassani & Parravicini, 1983). But the theoretical models from which I first started and with which whole volumes were written turned out to be built on ABSURD assumptions (van der Waals is so weak that the layers of boron nitride and graphite at room temperature would fly in the air, while these crystals can withstand 3000C) (Sharupin, 1976 ; Ordin, 2003).

That’s why I started to conduct research in a complex way. And in my experiments and conclusions I started from measurements of a number of different samples obtained by different technologies and using different techniques, including X-ray studies, electron microscopy of Nano-particles and Nano-flakes, etc. Only a small part of them is presented in this paper. So, the presented material is chosen just for the most obvious demonstration of the conclusions made. But the conclusions are made from numerous experiments and analysis, which included computer modeling, which is not presented in this paper at all. And some details of the presented work can be found in my previously published articles and books (Ordin, 2018 ; Ordin, 2018 ; Ordin, (n.d) ; Ordin, (n.d) ; Ordin, (n.d) ; Ordin, 2020 ; Ordin et al., 2004 ; Ordin, 2021 ; Ordin, 2021), where you can further familiarize yourself with some aspects of these studies, directly related to the clarification of the Fundamental Laws themselves.

Physical States of Matter

Humans are material (at least so far as it is believed) and materially dependent (without any assumption). And no matter how immersed you are in solving purely scientific problems, the processes taking place in this material human environment will inevitably affect you as well. But for now, let us abstract away from social problems, so as not to make the mistake of solving purely physical problems.

The main differentiation of matter states on the macroscopic scale by categories: gas, liquid, solid, we do on the organoleptic level, i.e. with the help of sense organs given to us by Nature: breathing, swimming, building. Smell, taste, sound and light have allowed us to make a more subtle and more abstract differentiation: salty-sweet can be both liquid and solid, and

sometimes even gaseous. Although we can easily distinguish the sound of a splashing wave from a rock fall and a peal of thunder. We can, with the help of sight, at first approximation, distinguish the solid bump from the slime in the swamp and, in living “matter,” distinguish the bastard from the righteous.

The subtle differentiation of matter by humans gave birth to the Technique of Measurement. But originally it was not quite subtle, or rather not subtle at all - a crude measurement of the characteristics of matter, such as size, mass, force. Even animals are able to make such assessments and the Mouska is unlikely to bark at the elephant. But CONSCIOUSLY, people have already thought abstractly even from such coarse measurements about intangible atoms and infinitely small values of length and time. But the development of Measurement Technique allowed qualitatively widening the Measurement Limits, much wider than the organoleptic ones, in principle aiming at infinitely small and infinitely large values, far exceeding the “human sensibility range”. And the problem of Measurement Interpretation arose. In a huge array of data, in principle, it is easy to get confused and “look for a black cat in a dark room when it is not there”, especially when there is a temptation to assume that the Measurements gave something not at all connected with organoleptic.

But for all that, in this huge number of data, almost chaotic for our Mind, ELEMENTARY Organoleptic was and remains an essential Orientation. When in Mexico a bat was hit like Oleg Taktarov’s head, it was not just the existence of the bat that was material, but quite tangible (organoleptic ally) and the speed of its movement. It is just necessary to consider the state of matter not only static, but also dynamic.

But for complete understanding of Matter it is very essential to introduce, in principle, an abstract concept of the FLOW, which characterizes properties of a (quasi-)continuous medium, the internal structure of which is insignificant for our consideration or is not available (yet unknown to us). Although the work is devoted to the solid state, but without a clear understanding of the Fundamental Concepts we will pass to the discussion of a purely polymeric state after clarification of the Field concept as well.

We can easily feel the mechanical stress field in a finger by clamping it in a vise. Just as easily we can “feel” by the broken windows and the field of the sound wave. And just as easily we can feel the light field as a blinding flash and as a tan on the body. With our Psyche (not organoleptic) we can sense both biological and psychological fields, as the same “pandemic” in which the psychological component is markedly superior to the biological. But as Academician Alexandrov said in a TV show, “A field is something that can be BELIEVED!” Alexandrov, as a mathematician and physicist, naturally meant to measure with physical instruments, i.e. devices that reliably and unambiguously expand and refine our organoleptics. As such, the devices of the vine-seekers are very difficult to classify as such. And psychological “measurements,” though their description occupies volumes of psychology, are only

being tried in crude models with the help of digitization of psyche. But the problem of “Cognize Understanding” is largely social and in this purely physical work on the polymeric state of matter, we will not touch, as I said above.

The measurement of force and weight was one of the first organoleptic measurements, which is actually what Newton formulated as the Law of Universal Gravitation. So, in fact, Newton reliably connected our organoleptic sensations with the static field of forces and their potentials (the equipotential surfaces surrounding the body). Work-energy organoleptically, too, people learned to measure by the exhaustion-exhaustion of the same slave. So, too, they could estimate the difference in potentials by the energy the stone would gain when it fell from the mountain.

So both parameters of the Gravitational Static Field used by Newton were Physically Measurable, which allows them to be interpreted as strictly related to Reality. We are just used to living in this POLE without noticing it, but we feel it very well when we want to sit down or even lie down. So there is no REASON to believe that the gravitational field is not material. Just as there is no reason to believe that other static fields, such as the Coulomb field, are immaterial. For the same light, unlike fake gravitational waves, we have already learned to MEASURE its pressure. Returning to the definition of the POL as a property of (quasi-)continuous medium, we can only, to some extent conditionally, divide it into static and dynamic properties of the material medium only.

In this respect also the polymeric state is intermediate between purely static and purely dynamic characteristics of the material medium. But the main confusion, to which Einstein was involved, is that the material properties of the POL are attributed to an abstract ruler, which we measure Space and Time with. Although it is more the fault of the developers, who forbade the publication of his own article, where he “exposed” gravitational waves originally declared by him. The developers of the Theory of Relativity did not understand the main thing - Einstein, based on Galileo’s Principle of Relativity, deduced that the propagation of perturbation in the FOL has a finite speed and put it equal to the speed of light. And what belongs to the FLY, the developers attributed to the SPACE. The substructure of the FLOW, both for static gravitational and static electric fields, is not strictly established by us yet. But how it, in principle, can be determined is shown in the book “Foundations of Planck-Einstein Quantization”.

And moving specifically to the material medium called a solid, then reliably proven model of its microstructure is a set of ideal points with the mass of the nucleus, surrounded by electronic orbitals, which provide their interaction and quasi-stationary (in general case - metastable) state of these points, which in turn, also performs thermal fluctuations.

Structural units of polymers and their bonds

Behind the common name polymers lies a whole class of compounds formed by the multiplication of some

with a step of half a micron, observed when the radiation is polarized perpendicular to isolated metal strips (Fig. 4).

Slightly higher in frequency of peak (c) and lower than it are smeared water absorption peaks (2) and (3), which are determined by the splitting off of the low-frequency vibration due to the large difference in the masses of bound ions. The last peaks of water absorption are also intramolecular, but somewhat blurred due to the quasi-amorphous state of water. But the peak of boron nitride (c) in frequency strictly corresponds to the chemical bond between its mono-atomic layers, which was not taken into account earlier, while the assumed van der Waals interactions correspond to vibration frequencies below 10cm^{-1} (unobserved IR range). Thus, the absence of absorption peaks in water at frequencies below peak (3) and above 10cm^{-1} shows that only liquid water can have a purely van der Waals relationship between clusters. Whereas in solid polymers, the bond between chains of molecules, as well as between the mono-atomic layers of boron nitride, is clearly a bond due to unaccounted for orbitals.

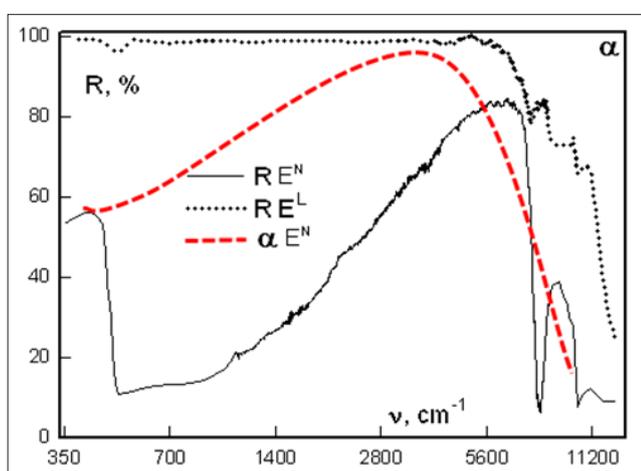


Figure 4: The peak of the reflection of the model structure of metal strips in the region of 5000cm^{-1} with an electric vector perpendicular to the strips (low-frequency reflection peak of about 300cm^{-1} from the fluorite substrate of the structure) and the corresponding wide absorption band (red dotted curve).

In addition, there is an additional absorption band on vibrations in the O-H residue of water dissociation. The concentration of H-O-H molecules and the O-H group determines the ohmic losses in the insulating films of capacitors obtained by anodic oxidation of foils of various metals: tantalum, niobium, aluminum, and it is reliably controlled by the absorption value in the corresponding IR absorption bands. There are also characteristic oscillations of electrons in orbitals at a high frequency. These high-frequency, bandgap-determining electronic oscillations give rise to the main high-frequency absorption peak and sea tan due to the high reflectivity of water in the ultraviolet region.

The energy stability of the water molecule determines its very weak tendency to polymerization at room temperature and its low boiling point of 373K . But, as can be seen from the comparison of the water absorption halo (Fig. 3) and the

artificial structure (Fig. 4), water has the ability to form weakly bound clusters from an ELEMENTARY molecule. This also follows from the pore size in the crystals, the structure of which is determined by the water of crystallization. So in mordenite these pores have a diameter of 6A , in zeolite - 20A , and in different opals - from 60 to 500A , which determines the splashing of light by opal in all colors of the rainbow. So, for water, we can also say that it also has a tendency to form chains, which is directly expressed in the tubes of mordenite with 6A that grow over them, and has a tendency to polymerize, primarily into "opal" clusters.

It is the conductivity inside such water clusters that also gives its gigantic permittivity at the low-frequency edge of Figure 2. Whereas the relatively thick van der Waals layer between the clusters actually limits the through flow of current through the water, limits it to flow only through those areas of their surface that mate them chemical bonds with neighboring clusters. And only this tendency of water to polymerization can be associated with an increase by tens of degrees of the boiling point of crystallization water in the pores listed above. But even this weak connection of ELEMENTARY molecules in clusters has no reason to attribute to van der Waals forces - strictly van der Waals liquids, inert gases boil at temperatures of a few degrees, and the vibrations corresponding to them, if they appear, are only at very low frequencies - at wavelengths greater than a millimeter.

Of course, such a broadening of the absorption bands could formally be associated with a large damping of these vibrations on bonds formed by neighboring chains of molecules. But, firstly, then it must immediately be recognized that it is not van der Waals, but these bonds that provide a chain of chains of molecules, and secondly, of course, damping itself leads to a decrease in the oscillation frequency, but it cannot be completely excluded, that the smearing of the bands of molecular absorption bands at the junctions of different chains reflects the distortion of the electronic bonding orbitals themselves, changing their rigidity and, their corresponding frequency.

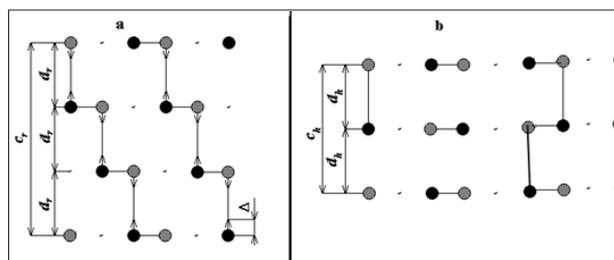


Figure 5: Schematic representation of the regular alternation of interplanar bonds in rhombohedral boron nitride (a) and the quasi-regular alternation of "flickering" interplanar bonds in hexagonal boron nitride.

Shown in fig. 2, the absorption band of boron nitride strictly corresponds to interlayer chemical bonds, which is in full accordance with the preservation of 4 outer electron orbitals per atom. And these interlayer bonds are strictly alternating

along the walls of the intralayer hexagons, and lead to the formation of single crystals of the rhombohedral phase with a translation period along the hexagonal axis equal to three times the interplanar distance (Fig. 5a).

And in the hexagonal phase, these “flickering” interplanar bonds, although chaotically scattered, are clearly manifested when the electric vector is polarized along the C axis in the form of a blurred (compared to that observed on a rhombohedral crystal - Fig. 2), but quite a powerful reflection peak. The randomness of the arrangement of interlayer bonds makes the total interlayer bond indistinguishable, but, but because the alternation of boron and nitrogen ions is superimposed, then the translation period in the hexagonal phase is equal to twice the interplanar distance (Fig. 5b). The hexagonal phase of boron nitride itself is a polymer, only formed not from chains of molecules, but from flakes with a predominant orientation of their C axis along the growth axis and about a hundred angstroms across and several tens of angstroms thick. At the same time, the low-frequency molecular bond is also preserved in the hexagonal phase (Fig. 2), and, as shown in the reflection spectra (Fig. 6), the high-frequency intralayer bond is also preserved.

In the amorphous (gamma) phase of boron nitride, which is fundamentally non-polymeric - the length of the chains tends to one molecule, randomly oriented relative to neighboring molecules, the intra-layer molecular bonds are strongly distorted, but the bonds formed with a higher concentration are close in rigidity to interlayer ones and in no way correspond to rigid bonds in the cubic phase (in diamond) (Fig. 6). These powerful chemical bonds are manifested in powerful absorption peaks and in a broad reflection peak, located just in the region of interlayer vibrations (Fig. 6). And these modified interlayer bonds determine the strength of amorphous boron nitride more than that of hardened steel.

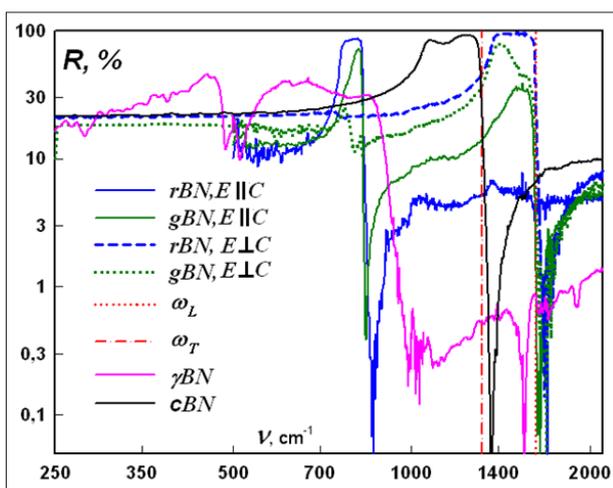


Figure 6: Lattice reflection of various modifications (phases) of boron nitride, for anisotropic phases, measured with radiation polarized parallel and perpendicular to the hexagonal C axis.

Recrystallization of polymers can be carried out by various influences, in particular, by ultraviolet, which breaks the

bonds within the ELEMENTARY molecule. At the same time, the ELEMENTARY molecule of the polymer also naturally changes. A similar recrystallization, but gently, by high-temperature annealing, but decomposing the ELEMENTARY molecule, was carried out in carborasilane in order to obtain silicon carbide nanoparticles. Comparison of the molecular absorption peaks of carborasilane, a single crystal of silicon carbide, and its nanoparticles (Okamoto et al., 1999) makes it possible to complete the picture of the transformation of molecular orbitals during polymerization as well (Fig. 7).

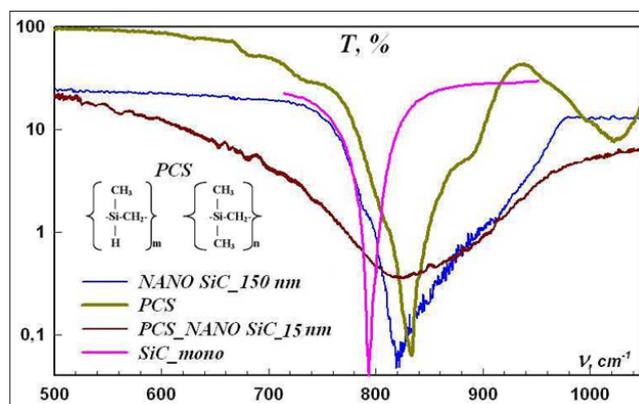


Figure 7: Comparison of absorption bands by a silicon carbide molecule in its various states.

As shown in Fig. 7, the least blurred molecular vibrations of silicon carbide are observed in the crystal lattice of a single crystal (for vibrations perpendicular to the axis of polytypism - pink curve) and in the polymer film of carborasilane. Small shifts of oscillation frequencies along the polytypism axis for different polytypes (Ordin et al., 2004) are not shown in this figure so as not to clog it. Something else is important. Namely, starting with sufficiently large nanoparticles, the fundamental vibration frequency increases. And in a carborasilane (PCS) film, these molecular vibrations are slightly shifted upward in frequency. The absorption at this shifted frequency in PCS is noticeably lower, even on a film an order of magnitude thicker than a single crystal, since the concentration of these bonds is much lower. Beyond the limiting frequencies of the above graph, there is a whole set of additional molecular bonds. But here they are not analyzed, their existence is simply stated, which is quite natural for a separate complex PCS molecule (Fig. 7).

The dynamics of the polymerization process, which is similar in many respects to phase transitions along a non-Lifshitz star in incommensurate crystals (Vakhrushev & Ordin, 2003; Bourgeois et al., 2004; Ordin, 2011), can be additionally considered using Teflon (fluoroplast) as an example. Like water, absorption bands corresponding to chemical bonds in the ELEMENTARY molecule. In non-polymerized fluoroplast compared to polymerized fluoroplast, they are broadened (Fig. 8), which corresponds to the disordering-distortion of molecular orbitals, both directly involved in the animation (internal, in shortened chains) and connecting different chains (external).

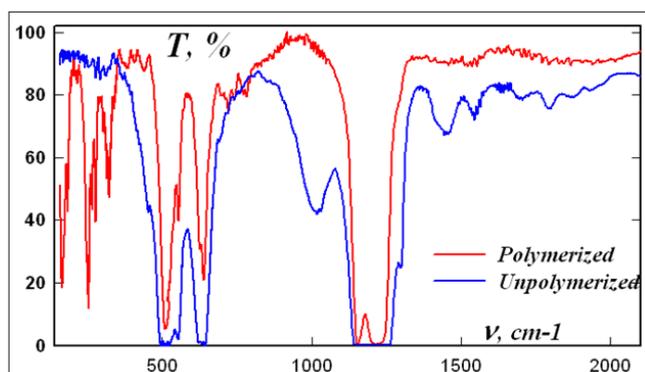


Figure 8: Transmission spectra of Teflon (fluoroplast) 15 μm thick, polymerized (red curve) and non-polymerized (blue curve).

But as follows from the transmission spectrum of polymerized Teflon, in a complex Teflon molecule there is also a whole set of additional lower-frequency electron orbitals, which can be considered and turn an unpolymerized into a polymerized one. And, judging from the weak blurring of these bands, indicating their high repeatability, both in the chain itself and in the bonds of the chains with each other, they determine the polymerization process itself. And judging by the isotropic and high strength of the polymerized film, these rather rigid molecular bonds form not just chains, but a network of Teflon molecules. In a soft, or rather, in a viscous non-polymerized Teflon film, only hard valence bonds take part in the formation of chains, as can be seen from powerful high-frequency absorption peaks, while relatively soft valence bonds corresponding to low-frequency vibrations and bonds between chains completely, as seen from the above spectrum, absent-broken. It is only in this semi-liquid state that van der Waals provides a very soft coupling of molecular chains in polymerized Teflon.

This is clearly manifested when the film is stretched along the chains. Due to the fact that the fragments of neighboring chains freely and straighten, slide over each other, not only the thickness of the film decreases, but also its width. The non-polymerized film used for measurements was initially anisotropic and its stretching perpendicular to the chains was more difficult and easily led to breakage. Now, after this analysis, it is obvious that measurements in polarized light, as was done with boron nitride crystals, would give direct rather than indirect confirmation of the described picture and would allow quantitative calculations of the parameters of molecular bonds in Teflon. But then, when these measurements were carried out, the task was purely applied - to select a combination of materials that are as transparent as possible in the far IR range AND "raw" Teflon coated, on the one hand, with boron nitride, and on the other hand, with black polyethylene, in fact, like a layer of glue) and allowed to make it possible to say the ideal required filter, and the protection of Teflon from direct contact with the atmosphere ensured stability - the absence of its surface polymerization as a result of exposure to the atmosphere

The fact that van der Waals makes an insignificant contribution

is also indicated by the fact that it practically does not manifest itself in any way in polyethylene, and in a number of other studied polymers transparent to the radio range, while these vibrations should be IR-active, since one of the main factors in the emergence of van der Waals is precisely the dipole interaction.

Some additional aspects of polymerization follow from consideration of specificity and growth in nature (Ordin, 2019; Ordin, 2020; Ordin, 2020).

Conclusion

The right choice of the Basic Model allows effective development of the technology. Thus, our joint research with B.N. Sharupin, the leading technologist of the USSR who created boron nitride, helped him to grow perfect crystals of rhombohedral boron nitride. In this case, confirmed by infrared spectroscopy, the small scale of Van der Waals forces helped to build models of some materials not abstract, but corresponding to their real nature - their crystal structure. Similarly, in order to create polymers with given properties, it is necessary to take into account, first of all, not the weak van der Waals sliding interaction, but the rigidly local atomic orbitals in the molecule.

The analysis of the limit states of molecular bonds in polymers concerned, first of all, the very definition of the macroscopic effective medium, to which, in contrast to the amorphous state, the near order is preserved, but after the scale given by the TIME of POLYMERIZATION, there is no correlation in the arrangement of atoms typical for monocrystals. For polymers-dielectrics, it is natural that a strictly similar state of atoms will appear for electronic levels as well. And discovered high-temperature superconductors possess, in principle, also a similar dielectric state. Therefore, one can use the TIME of POLYMERIZATION as an essential factor to better understand and improve the properties of traditional inorganic polymers with high super transition temperature, and one can try to create organic superconductors as well. At one time Brant tried to make them, by introducing, in particular, organics between the monoatomic layers of graphite. But this mistake too, Brant was still the same - traditional. He, like everyone else at the time, believed that the bond between the layers in graphite was Van der Waals. But in graphite, as well as in its dielectric counterpart boron nitride, the fourth electron, not involved in the intralayer bonds, forms an interlayer bond, which, in order to introduce a new molecule, must be broken. Our experiments with the late Anatoly Zadarozhny showed that not only Brant's pressures - units of kilo bars, but even tens of kilo bars are not enough to introduce foreign atoms into the interlayer space. Whereas polymerization of organics on the surface of rhombohedral graphite monocrystal is quite feasible. So is the joint polymerization of organics with monoatomic graphite layers, erroneously called "van der Waals graphene".

However, since the apparatus of Quantum Mechanics allows to calculate atomic orbitals very roughly (for the time being, I am going to continue correcting the Schrödinger equation now), it is necessary (for now) to start from reliably established

chemical bonds in the molecule. But not absolutizing them, because on the surface of the molecule, when interacting with neighboring molecules, they can be modified into generalized orbitals.

Thus, starting from the qualitatively correct Basic Model, it is possible to effectively search for new polymers, modernize previously created polymers, and create fundamentally new polymers. And at the same time, strictly calculate their properties, mechanical, electrical, and optical.

After all, it is the modified electron orbitals, which were not taken into account before and which bind molecules together in polymers, that provide the bonding of macromolecules. Not Van der Waals, as it is still mistakenly believed. Van der Waals provides only weak macroscopic adhesion of films. But, as it has been received in the described experiments on layered crystals, their splitting requires energy of orders of magnitude more, which strictly corresponds to the observed frequencies of interlayer oscillations. And taking into account the revealed new orbitals and taking into account the transformation of internal orbitals described in the work during the growth of the poly-molecule, and will make it possible to translate polymers into functional materials for electronics and optics. Also, high-performance thermoelectrics and electrolytes can be created on the basis of polymers, work on which was carried out back in the seventies of the last century, but a new characterization of polymers and recent studies open up prospects for them again (Ordin, 2017; Ordin, 2017; Ordin, 2020).

There is an additional aspect - the surface state of a macroscopic polymer sample as a limiting case of the surface state of a polymerized molecule. The analysis of this state will allow, in principle, to solve the problem of rejection of polymeric implants, which are much safer than the implants produced by biomedical technologies (ORDIN, (n.d)).

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