International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Improvement of Rheological Properties of Soil Structure Based on Lignite Dispersion

Mirzoev Akmal Akhadovich, Khodjayev Yanvarjon Djakhangirovich

Abstract— This article examines the change in stress and strain media, in particular natural leonardite (brown coal), prepared for grinding and during grinding, due to the restructuring of the material, i.e. changes in the relative position and deformation of the elements of the structure, including at the level of macromolecules that are inert to the deformation and relaxation processes, provide important for the technology to use improved rheological properties of the soil structure based on dispersion of leonardite, information about the physical properties of the material and its structure. The time variation of the stress in an inert-viscous-elastic medium with a constant strain rate depending on the values of the rheological parameters, it is possible to occur by three laws: aperiodic (steady), critical and oscillatory damp

Keywords: humus substance (HS), the dispersion medium, environmentally safe fertilisers, humic acids, rheologically complex environment, inert viscous and elastic medium model, relaxation model, relaxation equation, coal dispersion

I. INTRODUCTION

One of the directions of development of modern agriculture is the priority use of such natural compounds, which do not hurt the soil, and do not damage the production system as a whole, and ensure the production of environmentally friendly products. Special attention is paid to products obtained in natural environments, such as, in particular, biological protection of plants, fertilisers and regulators of growth and development, based on natural raw materials - peat, coal, algae, etc. The resilience of the biosphere to intensive human impact and its ability to restore is mainly due to the presence of humus substance (HS) in soil, which by its genesis represents a particular stage of physical, chemical and microbiological processes of transformation of organic matter in nature. The history of HS study is more than two centuries old. For the first time German chemist F. Achard (F. Achard, 1786). Singled them out from peat, so it was German scientists who developed the first schemes for the isolation and classification of HS, as well as introduced the term "humic substances" (derived from Latin humus - "land" or "soil"). In 1981, it was decided to create the IHSS (International Humic Substances Society) International Society for the Study of Humic Substances.

Manuscript published on 30 September 2019.

***Correspondence Author(s)**
Mirzoev Akmal Akhadovich, Senior Researcher, Institute of Mechanics and Seismic Stability of Structures of UzAS
Khodjayev Yanvarjon Djakhangirovich, Lead Senior Researcher, Physical-Technical Institute of SPA "Physics-Sun" of UzAS

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

The uniqueness of their properties and structure determine soil formation processes and soil fertility, as well as the decomposition of rocks and minerals, binding, fixation, concentration, dispersion and re-deposition of chemical elements. Natural HS regulate plant growth processes, improve physical and chemical properties of soil, activate the activity of microorganisms, influence the migration of nutrients, stimulating the processes of breathing, synthesis of proteins and carbohydrates, enzymatic activity The traditional use of leonardite or lignite (not reaching the brown coal level) as a fuel should be considered as the destruction of valuable natural product, organic fertiliser and chemical raw materials. Efficient use of leonardite (lignite) can be envisaged in agriculture or environmental technologies for the protection, mainly due to its chemical properties and as a potential source of HS. The use of leonardite (lignite), either in its natural state or after minimal treatment, is the most cost-effective way. However, direct applications of leonardite (lignite) have some disadvantages. Leonardite, which is dusty and dark brown or black, is not a "convenient" material: the use of natural leonardite as a "soil conditioner" is based on the physical decomposition of dispersed (solid) particles of lignite (weathering), during which active humic species should be released. The use of natural leonardite as an alternative form in agriculture, as well as for soil restoration in situ is a form of liquid or soft solid hydrocolloid. Lignite hydrocolloids can be prepared using straightforward mechanical water dispersal procedures, during which part of the solid matrix is structured into a dispersion phase, which then serves as a dispersion medium (suspension) for the remaining small solids. The dispersion medium (liquid-water) can be supplied, for example, with nutrients or plant substances that contribute to the release of humic components. The hydrocolloid form prevents unpleasant vortexing of lignite dust (particles), and mechanical influence allows to release a part of organic (humic) fraction from solid material in a dispersion phase in which it is possible to apply a natural fertiliser. Despite this simplicity, very few scientific papers have been published that mechanical study processes of structure formation and structural destruction [1]. HS or humic acids are involved in natural processes, so their role in the transfer of useful and harmful species into nature is essential. Structural modelling of humic acids has been the object of research for many decades, and still much key information is missing or insufficient. Mathematical modelling of structural formation and structural destruction processes, as well as for their possible application in further improvement of HS parameters, such as particle size, viscosity, and other rheological properties and structural formation to be essential [1, 2, 6].

HS production is a remarkable natural compound that plays a vital role in natural processes [3, 4]. This fact, associated with the colloidal size of humic acids, plentiful native availability and relatively inexpensive methods of extraction, creates an essential material for practical application. The size and shape of the particles, as well as their molecular weight, can be specified as the main parameters to be taken into account in case of investigation of the complex structure formation process, reactivity, as well as in possible further expedient application of HS. Experimental studies are caused by difficulties mainly due to the lack of education of the above, as well as the multiphase and polydispersity properties of humic materials, including natural leonardite.

In recent decades, there has been a steady increase in interest in various factors of application of HS, primarily in crop production, animal husbandry, the protection of natural environments from pollution and some industries [5, 7 - 10]. Industrial humic preparations (HP), obtained from natural resources (leonardite, coal, peat, bottom sediments, multi-tonnage organic waste, etc.), mostly inherit the properties of HP of raw materials and, therefore, by their functional activity act as meliorates and preparations for detoxification, remediation and reclamation of degraded and polluted soils, as well as plant growth stimulants. In the world production of HP the developments from the carbon materials prevail: low caloric lignite and low caloric oxidised brown coal and lignite corresponding to it in the English-speaking terminology. Leonardite and humanity also belong to eroded, oxidised brown coal, often associated with shale coal. Peat and sapropel GPs are the most popular in the Russian market.

It is a rare organic product on the ground that solves the problem of erosion, increased pH and salinity due to excessive use of chemicals — known as the land regulator. When using leonardite for traditional agriculture, ornamental plants indoors and outdoors, it has the following benefits: it physically improves the rheological structure of the earth, enriches it with organic matter, provides ventilation and nutrients, and develops the microbiological properties of the planet. As a result, the roots of plants become healthy, use natural fertilisers - leonardite, regulate the water balance and increase the water retention capacity of the earth, and thus reduce the frequency of irrigation, increases the resistance of plants against drought. Also, keeping the land moist, prevents yellowing of plants in hot and dry climates, as well as prevents erosion and salinisation of soil, thus helping to recover from salinisation due to the excessive use of chemicals or naturally saline soil. In the process of interaction of the land structure in the fertilizer zone, it is connected by particles of the earth and forms rheologically difficult environment, as a result of which humus is formed in the ground, which increases seed growth, development of the fruit and resistance of the plant to frost, as a result provides early maturation of high-quality products, provides completeness of natural color, taste and appearance.

Leonardite in the form of fertilizer introduced into the soil in the crushed form removes salt and lime from the root of plants, as well as regulates the toxic contamination and high alkalinity formed by residues of chemicals and pesticides, thereby making the soil healthy, strong and ready for the functioning of microorganisms and increases the amount of organic matter in it, as well as supports macro-and micro-nutrients. The property of its abundant humic acids changes ions and creates a complex of natural substances and metals, and thus changes the structure of minerals in the soil in the form of various oxide compounds and releases them. As a result of these complex physical and mechanical processes, which are not sufficiently studied, turns free metal ions into organic forms and, thus, contributes to the natural, sufficient and periodic absorption of roots. Obtaining nutrients and pigmented substances by plants contributes to the fact that plants become healthier, stronger and more resistant to external influences, fruits become larger and equal in size, more attractive and mature.

In recent years, there has been a significant increase in research on the problems of shredding - the dispersal of materials - due to its enormous practical importance. Solution of complex issues of material grinding will allow improving the technology of almost all industries, but the resolution of these issues is impossible without knowing the patterns of change in stress-strain states in the process of deformation and destruction, the existing structure of the body and the formation of new materials with new properties [6, 11, 12].

In this connection, this paper considers the issues of stress changes in time in an inert visco-elastic medium based on the relaxation model proposed in [6].

Taking into account the properties of deformability in an accelerated manner and inertia of the visco-elastic medium leads to the equation of stress relaxation to the form [6]:

$$\ddot{\gamma}_{ij} = f_3^{-1} G_i^{-1} \ddot{\tau}_{ij} + 2 f_1^{-1} \mu_i^{-1} \dot{\tau}_{ij} + f_2^{-1} m_{\ell i}^{-1} \tau_{ij} \quad (1)$$

Assuming we get $\ddot{\gamma}_{ij} = 0$:

$$(f_3 G_i)^{-1} \ddot{\tau}_{ij} + 2(f_1 \mu_i)^{-1} \dot{\tau}_{ij} + (f_2 m_\ell)^{-1} \tau_{ij} = 0 \quad (2)$$

Lower the voltage tensor indices and present the solution of the last equation in the form:

$$\tau = Ce^{\alpha t} \quad (3)$$

Since the exponential function is dimensionless, the C constant has a voltage dimension, and α is inverse to the time dimension. Counting C =const, differentiating equation (3) by time and substituting it with (3), we obtain:

$$Ce^{\alpha t}(f_1 \mu_i f_2 m_{\ell i} \alpha^2 + 2 f_3 G_i f_2 m_{\ell 1} \alpha + f_3 G_i f_1 \mu_i) = 0 .$$

It follows that when $Ce^{\alpha t} = 0$ is a trivial case, or

$$f_1 \mu_i f_2 m_{\ell i} \alpha^2 + 2 f_3 G_i f_2 m_{\ell 1} \alpha + f_3 G_i f_1 \mu_i = 0 \quad (4)$$

Deciding (4) on, we find

$$\alpha = -\frac{f_3 G_i}{f_1 \mu_i} \pm \sqrt{\frac{f_3^2 G_i^2}{f_1^2 \mu_i^2} - \frac{f_3 G_i}{f_2 m_{\ell i}}} .$$

Then the decision (3) will look like

Retrieval Number: K25480981119/19©BEIESP
DOI: 10.35940/ijitee.K2548.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

$$\tau = C\exp\left[-\frac{f_3G_i}{f_1\mu_i} \pm \left(\frac{f_3^2G_i^2}{f_1^2\mu_i^2} - \frac{f_3G_i}{f_2m_{\ell i}}\right)^{1/2}\right]t \quad (5)$$

(5) shows that there are three possible voltage-time dependencies. Entering the designation $\left(f_3G_i / f_2m_{\ell i} - f_3^2G_i^2 / f_1^2\mu_i^2\right) = \omega'$ we get following case

The first case. Difference $f_3^2G_i^2 / f_1^2\mu_i^2 - f_3G_i / f_2m_{\ell i}$ positive or ω' >0. Then the solution describes an aperiodic (strong) voltage attenuation. By entering the symbols in the form:

$$p = \frac{f_3G_i}{f_1\mu_1}, \quad q = \left(\frac{f_3^2G_i^2}{f_1^2\mu_i^2} - \frac{f_3G_i}{f_2m_{\ell i}}\right)^{1/2}, \quad (6)$$

The decision (5) will be written down as $\tau = e^{-pt}(c_1e^{qt} + c_2e^{qt})$. Assuming F=$c_1$+ c_2, Φ = c_1 - c_2, we get:

$$\tau = e^{-pt}(Fchqt + \Phi shqt)$$

or

$$\tau = e^{-pt}\left(\frac{F}{2}(e^{qt} + e^{-qt}) + \frac{\Phi}{2}(e^{qt} - e^{-qt})\right).$$

If t = 0, τ = 0, so must accept F = 0. Hence we get:

$\tau = \Phi e^{-pt}\, shqt$.

The analysis of the maximum voltage value shows that the voltage velocity is zero only once, so the voltage, in this case, is zero at this time:

$$t = \frac{1}{q}Arthq/p$$

has one maximum

$$\tau = \Phi e^{\frac{p}{q}Arth\frac{q}{p}} \cdot sh(Arth\frac{q}{p}). \quad (7)$$

The second case. If $f_3^2G_i^2 / f_1^2\mu_i^2 = f_3G_i / f_2m_{\ell i}$ or $f_3G_i = f_1^2\mu_i^2 / f_2m_{\ell i}$, it is the same as ω' =0, we will get a solution for critical voltage attenuation in the form:

$\tau = Ce^{-pt}$ 8)

This is the limiting variant of the first case at q, varies from positive to negative values. The quadratic equation for α has the same roots, so the C constant in the solution should be written in the form:

$C = A + Bt$ (9)

where A and B are constants, defined from the initial conditions.

Taking into account (9) decision (8) we will write it down as follows:

$\tau = (A + Bt)\, e^{-pt}$.

Under initial conditions t = 0, $\tau = \tau_0$, $\dot{\tau}$ = 0 we have:

$$\tau = \tau_0 e^{-\frac{G}{\mu}t}.$$

Thus, we obtained the law of Maxwell's stress relaxation [11, 12].

The solution (8) taking into account (9) and at t = 0, τ = 0, $\dot{\tau}$ = V_τ will take the form:

$\tau = V_\tau\, t\, e^{-pt}$.

From here we find the maximum value of the voltage speed in the form:

$$\dot{\tau} = V_\tau e^{-pt} - V_\tau tPe^{-pt}.$$

Therefore, at the moment $t = f_1\mu_i / f_3G_i$, we have

$$\tau = V_\tau te^{-pt} = 0{,}368\frac{f_1\mu_iV_\tau}{f_3G_i}$$

In the bodies which do not possess deformation-inert properties, pressure relaxes for the minimum time.

It follows from the above that Maxwell's relaxation equation describes critical stress attenuation and is a particular case of relaxation equation (2).

The third case. Attenuation corresponds to the condition $f_3^2G_i^2 / f_1^2\mu_i^2 < f_3G_i / f_2m_{\ell i}$, or ω' <0. The value $\left(f_3^2G_i^2 / f_1^2\mu_i^2 - f_3G_i / f_2m_{\ell i}\right)^{1/2}$ is imaginary and, therefore, (5) can be written in the form:

$$\tau = ce^{-\frac{f_3G_i}{f_1\mu_i}t}\, e^{\pm i\left(\frac{f_3G_i}{f_2m_{\ell i}} - \frac{f_3^2G_i^2}{f_1^2\mu_i^2}\right)^{1/2}t}. \quad (10)$$

The dimension of the inverse $\left(f_3G_i / f_2m_{\ell i} - f_3^2G_i^2 / f_1^2\mu_i^2\right)^{1/2}$ of the time dimension.

Having written down the exponential function in the form of $e^{i\omega' t} = \cos\omega' t + i\sin\omega' t$, and (5) we come to the conclusion that the voltage oscillates with frequency ω' .

Assuming in (2) $f_1\mu_i \to 0$, we obtain:

$$\ddot{\tau} + \frac{f_3G_i}{f_2m_{\ell i}}\tau = 0. \quad (11)$$

Integrating equation (11), we have

$$\tau = A\cos\omega t + B\sin\omega t, \quad (12)$$

where $\omega^2 - f_3G_i / f_2m_{\ell i}$

It follows that the voltage will oscillate harmoniously without fading.

In (12) A and B are constants determined from the initial conditions. If $A = a\sin\varphi$, $B = a\cos\varphi$, then

$$\tau = a\sin(\omega t + \varphi). \quad (13)$$

The maximum value of the function $\sin(\omega t + \varphi)$ is one, so the voltage amplitude a is the maximum value of the voltage.

For comparison (10), let's make it look like (13). In this connection (10) we will rewrite it in the form:

$$\tau = ce^{-\frac{f_3G_i}{f_1\mu_i}t}(c_1e^{i\omega' t} + c_1e^{-i\omega' t}), \quad (14)$$

supposing $c_1 = \frac{A}{2i}e^{i\varphi}, c_2 = \frac{A}{2i}e^{-i\varphi}$,

where A и φ are constants, defined from the initial conditions.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

Now (14) will take the form

$$\tau = Ae^{-\frac{f_3 G_i}{f_1 \mu_i}t}\sin(\omega' t + \varphi). \qquad (15)$$

This conversion is equivalent to using the initial condition $\tau = A \sin \varphi$ at $t = 0$.

The difference between the attenuating voltage fluctuations (15) and the non-absorbing voltage fluctuations (12) is the difference in the frequency of the changes. Also, in the case of attenuation, the amplitude of oscillations contains an additional exponential factor $\exp\left(\frac{f_3 G_i}{f_1 \mu_i}t\right)$, which decreases monotonically with time.

II. RESULTS

Changes in voltage in time in the inert visco-elastic medium corresponding to the above studied three cases of ratios of rheological parameters of the material under consideration are shown in Figures 1, 2, 3.

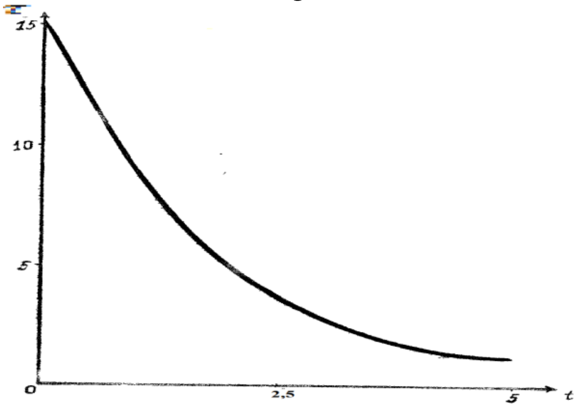

Fig.1. Critical voltage attenuation at ω' =0

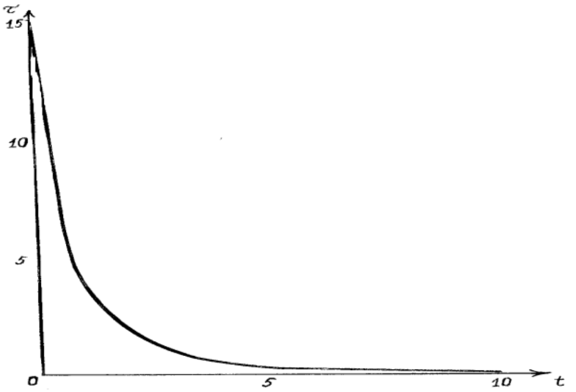

Fig.2. Strong voltage attenuation at $\sqrt{-\omega'} = 5$

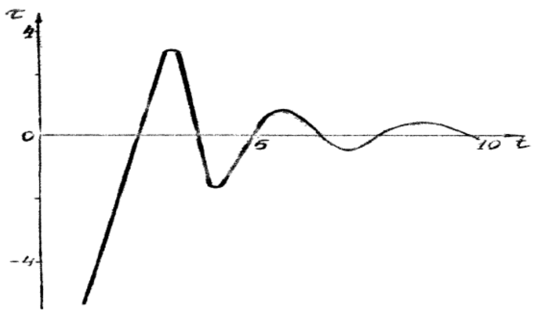

Fig.3. The harmonic voltage relaxation curve corresponds to the case when ω' =1

Thus, it is established that the change in time of stress in an inert visco-elastic medium at a constant rate of deformation depending on the values of rheological parameters can occur on three laws: aperiodic (strong) attenuation at $f_3 G_i > f_1^2 \mu_i^2 / f_2 m_{\ell i}$; critical mitigation at $f_3 G_i = f_1^2 \mu_i^2 / f_3 m_{\ell i}$; oscillatory attenuation at $f_3 G_i < f_1^2 \mu_i^2 / f_3 m_{\ell i}$.

Humic acids participate simultaneously in processes of structuring and destruction of soil, accumulation of nutrients and trace elements in the form accessible to plants, regulation of geochemical flows of metals in aquatic and land ecosystems. By the end of the XX century, one of the main problems of which was the chemical pollution of the environment, HS, as already mentioned, began to play the role of natural detoxicates. It is known that the most active free toxicant, bound substance is not so dangerous, because it loses bioavailability [13]. It turns out that the primary source of humic substances in the waste of brown coal mining, and this fully corresponds to the basic principles of "green chemistry". Lignite reserves in the world exceed 1 trillion tons. [13]. At present, Uzbekistan has explored coal reserves of 1 billion 832 million 800 thousand tons. Thus the explored stock of brown coal makes 1 billion 786 million 500 thousand tons, stone - 46 million 300 thousand tons. Projected resources amount to more than 323 million tons. Currently, coal mining is carried out at three deposits of the republic: Angren brown coal deposit, Shargun and Baisun coal deposits. Specialists of OJSC Uzbekugol plan to increase coal production 4.7 times by 2020 from 3.8 million (2013) to 18 million tons. Therefore, Uzbekistan with other Central Asian countries, as well as with the direct participation of the UN multi-partner trust fund (UN General Assembly Resolution No. 72/283 of 22 June 2018) has real prerequisites for comprehensive solutions aimed at mitigating the environmental and socio-economic consequences of the drying up of the Aral Sea.

In view of the above, the study of changes in stress and deformation, in particular of natural leonardite (brown coal), prepared for grinding and in grinding, is conditioned by the restructuring of the material structure, i.e. changes in the relative location and deformation of structural elements, including at the level of inert to deformation and relaxation processes of macromolecules, provide important for the technology to improve the rheological properties of soil structure based on the dispersion of leonardite, information about the physical properties of the material and the information about the physical properties of the material. The change in time of stress in the inert visco-elastic medium at a constant rate of deformation depending on the values of rheological parameters can occur on: aperiodic (energetic), critical and vibrational attenuation.

Retrieval Number: K25480981119/19©BEIESP
DOI: 10.35940/ijitee.K2548.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

REFERENCE

1. Scrumm G. Fundamentals of practical rheology and rheometry. Per. from English under the editorship of V.G. Kulichikhin. Moscow: Colossus, 2003. p.312
2. Astarita, J. Fundamentals of hydromechanics of non-Newtonian liquids (in Russian) / Per. - – p.310.
3. Klučáková M.,Omelka L. Sorption of Metal Ionson Ligniteand Humic Acids. Chem. Pap. 2004, 58, p.170-175.
4. Pekař M. Water, Air, Soil Pollut. 2009, 17, p.303-312.
5. Barančíková G., Senesi N., Brunetti G. (1997): Chemical and spectroscopic characterization of humic acids isolated from different Slovak soil. Geoderma, **78**: p.251–266.
6. Mirzoev A.A. The flows of multiphase with complex considering volume content phases // TIIF-2015. Proceedings of the Tashkent international innovation forum,19-21.05.2015., Tashkent, - pp.165-169.
7. Ramos-Tejada M.M., Ontiveros A., Viota J .L., Duran J.D.G. Interfacial and rheological properties of humicacid/hematite suspensions. J. Colloid Interface Sci. 2003, 268(1), p.85-95.
8. Ramos-Tejada M.M., Ontiveros A., Plaza R. C., Delgado A.V., Duran J.D.G. A rheological approachtothe stability of humic acid/clay colloidal suspensions.Rheolog.Acta 2003, 42(1-2), pp.148-157.
9. Khil'ko S.L., Titov E.V., Fedoseeva A.A., Tretinnik V.Yu. Effect of temperature on rheological properties of water-coalsuspensions and their plasticization by salts of humic acids. Khim. Tverd. Topl. (Moscow, Russ. Fed) 2003, (6), pp.27-36.
10. Kroshilin, V.E., Khodzhaev, Ya.D. Unsteady-state vapour-droplet flow in a heated channel. Inzhenerno-Fizicheskii Zhurnal. 1991, Vol. 61, No 6, pp. 939-946
11. Chhabra R.P., Richardson J.F. Non-Newtonian flow and applied rheology. Butterworth-Heinemann, USA, 2008.
12. Larson R.G. The Structure and Rheology of Complex Fluids. Oxford: Oxford University Press, 1999.
13. Perminova, I.V. Guminovye Substances - a Challenge for Chemists of the XXI Century. // Chemistry and life. - – 2008. - №1. - M.: - p. 50-55.

Retrieval Number: K25480981119/19©BEIESP
DOI: 10.35940/ijitee.K2548.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.