energy in Nigeria necessitates the need for adequate measures on the security of the country's nuclear material and facilities [1]. This study addresses the necessary security measures for the Nigerian Nuclear Power Plant Project. The article analyses the fundamental security measures in developing a Nigerian Nuclear Power plant Project, seen that insecurity posed by local terrorist groups, kidnappers, and armed bandits may affect the smooth operation of the nuclear power plant [2].

The imperatives of ensuring greater nuclear security in Nigeria lies in the fact that the country has embarked on an ambitious civil nuclear program with nuclear infrastructure that needs to be secured adequately, using radiological materials in many sectors and chances of their misuse cannot be ruled out. Above all, Nigeria is situated in a volatile region, and hence, vulnerable to nuclear terrorism [3].

Therefore, this study takes a comprehensive look at the approach to nuclear security in Nigeria, and critically examines the security measures that the country has to put in place [4, 5]. Particular focus is placed on the evolution and strengths, as well as weaknesses, of the country's nuclear security institutions, instruments, practices, and culture. Since the strengthening of Nigeria's nuclear security governance is an ongoing endeavor, the article puts forward many policy recommendations.

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PREDICTION OF THE BIOACTIVITY OF PLA AND CALCIUM PHOSPHATE COMPOSITES

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In In the last decade, poly (L-lactide) and calcium phosphates (CPh) biocomposites have attracted much attention due to their ability to exhibit osteoconductive and osteoinductive properties, biodegradability and sufficient mechanical strength [1]. However, the low miscibility of apatite in the polymer phase, does not allow to obtain composites with a high content of the mineral phase. In our previous studies, we have reported ways of introducing CPh into the polymeric matrix up to 30% wt to produce 3D-printed products. Here we describe a composite with a mineral phase content (up to 50%) in a polymer matrix. Our approach includes the introduction of sorbitol and glycerol, which contribute to the uniform distribution of CPh in PLA, which ensures the stability of 3D-printing and mechanical strength of the composite [2].

The purpose of this study was to obtain a composite based on PLA with the introduction of CPh in the amount of up to 50% with the preservation and improvement of mechanical properties, as well as comparative testing of bioactivity in vitro of materials with different content of CPh.

The samples were printed by the method of layer-by-layer melt deposition on a 3D-printer Ultimaker2 with a modified print head. Mechanical tests were performed by using various setups: compression and flexural on Instron 5985 and Charpy impact tests on Instron CEAST 9340. The properties of bioactivity and bio-mineralization were evaluated by immersing samples of composites in a simulated body fluid (SBF). Solutions was prepared in accordance with the instructions of the International Organization for Standardization ISO / FDIS 23317.

Table 1 shows the strength characteristics of the samples obtained with the set printing parameters. The compressive strength of composite samples increases from 55±2 to 64±2 MPa (by 16%) with an increase in the CPh content from 10 to 50. Impact strength of Charpy increases by 84% in this series of compositions and varies from 3.9 ± 0.5 to 5.2 ± 0.5 kJ/m2.

Tab.1. Mechanical properties of PLA and composites PLA/CPh

The ratio, wt.%			Compressive strength, MPa	Flexural strength, MPa	Impact strength of Charpy, kJ/m^2
CPh	PLA	Glycerol			
0	100	0	52	42	3.9
10	88	2	55	43	4.09
30	66	4	62	46	5.11
50	44	6	64	47	5.21

Sample testing in SBF revealed that samples containing CPh showed a marked increase in weight during the first seven days of incubation in the SBF. The sample containing 30% CPh had a weight gain of 22%, the sample containing 50% CPh had a weight gain of 45%. Pure PLA samples showed no increase in weight during this period. At the end of 28 days the increase in weight was: 23% 67%, 83% for PLA/ CPh (10%), PLA/ CPh (30%), PLA/ CPh (50%), and 12% for pure PLA. X-Ray test indicates presence of mostly hydroxyapatite on the samples surface and some amount of other calcium phosphates and amorphous phase. Thus, samples containing more CPh as a mineral phase form a richer apatite layer.

In order to ensure stable printing and acceptable values of mechanical properties of composites depending on chemical homogeneity of filament, sorbitol and glycerin were introduced into its composition at the stage of mixing. Mechanical characteristics of the composites of the developed compositions correspond to and exceed the natural bone parameters and considerably exceed the characteristics of calcium phosphate ceramics. 3d-printed nets made of PLA/CPh showed higher biological activity at contact with SBF than pure PLA.

Thus, the increase in the share of CPh in the composition with PLA up to 50% leads to improvement of mechanical properties and bioactivity of the composite material in test in vitro.

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THE DYNAMICS OF ENERGY RELEASE IN A HYBRID REACTOR OPERATING WITH GDT-FNS IN A PULSE-PERIODIC MODE

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Specific characteristics of a spatial hybrid thorium reactor with an extended neutron source based on the magnetic trap were studied in the work. The researched “fission–fusion” reactor facility is essentially a hybrid reactor with the reactor core which consists of the fuel blocks assembly of the unified construction of high temperature gas-cooled thorium reactor HTGR and a long magnetic trap (GDT-FNS) which permeates the near-axial reactor core region [1]. In the researched configuration of the hybrid unit the high-temperature plasma pinch is formed in the pulse-periodic mode. At certain pulse ratio (duty cycle) it should be expected that fission “wave” diverging from the axial region of the system and spreading over the fuel assembly volume is formed in correlation with the pulsed source of fast D-D neutrons by time. Thus, at such conditions it is essential to research the fission “wave” spreading process and, consequently, the formation of energy release distribution in the assembly volume.

The work studies the stationary and spatio-temporal characteristics of neutron fluxes and the energy dynamics of the stadied facility. The research result shows: (1) At the moment of the facility start-up for “cold” blanket GDT-FNS should provide steady intensity of D-D neutrons generation in the range from 1016 to 2×10^{18} neutrons per second from the total plasma column. (2) When the pulse duration is 1 ms and pulse ratio is 2, GDT-FNS, which operates in the required range of D-D neutrons generation, will provide warming of the blanket with the speed of 10 ($K \times h^{-1}$), that meets the requirements of thermal technical engineering reliability at cold start-up. (3) To maintain $k_{eff}(t)$ at constant level GDT-FNS should constantly power the reactor core with additional neutrons, while the intensity of D-D neutrons generation should grow continuously during the whole fuel campaign. The stationary neutron-physical characteristics and the spatio-temporal propagation of the fission wave were modeled using the PRIZMA software package developed at the Federal State Unitary Enterprise RFNC-VNIITF named after Academician E.I. Zababakhin. It can be stated that the obtained results proved the possibility of using the program software PRIZMA, developed in VNIITF to provide the whole list of full-scale computations of hybrid facility neutronic characteristics in various operation modes of the thermonuclear neutrons plasma source.

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