

Detection and assessment of off-center nuclear material using the active rotation method

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INTRODUCTION: We have developed a new nuclear material detection method, called the active rotation method, using a neutron rotation machine that rotates a neutron source (Californium-252) at a speed of thousands of rpm. In this method, a water Cherenkov neutron detector (WCND) has been used for a neutron detector. This system is low-cost and transportable. Previous studies have demonstrated the effectiveness of this method, such as in the detection of gamma-ray shielded highly enriched uranium (HEU). However, in previous research, the measurement object was placed at the center position, defined as being aligned on the axis between the center of the rotation device and the neutron detector. In this study, we attempted to detect nuclear material in off-center locations and investigated a method to determine the presence or absence of such displacement.

EXPERIMENTS: The rotation machine can rotate the disk (32 cm in diameter), where a neutron source is installed at its outer periphery, at a rotation speed between 0 and 4000 rpm. A neutron source of Californium-252 whose activity was 1.0 MBq was set in the disk. The size of the WCND is 30x25x30 cm, with four 2-inch PMTs mounted on the ceiling. The WCND was covered with boron-rubber to shield against thermal neutrons. Furthermore, 5-cm-thick lead blocks were placed in front of the WCND to shield gamma-ray generated from water and polyethylene. Between the lead blocks and the rotation machine, polyethylene blocks of 40x25x30 cm were positioned, which contained a 20x20x20 cm internal cavity for placing the measurement object. As for the measurement object, approximately 1 kg of low-enriched uranium (LEU) with an enrichment of about 20 % was used. The rotation speeds were 600 rpm for low speed and 4000 rpm for high speed. In the active neutron method, the presence or absence of nuclear material is determined using an evaluation-value derived from the ratio of integrated counts around the peak at both low and high rotation speeds. Each measurement took 20 minutes, since this method requires both low and high speeds, the total measurement time per case was 40 minutes.

RESULTS: Figure 1 shows an example of the measurement result at 4000 rpm with nuclear material placed at the center position; a distinct peak is observed around 6500 μ s. In this case, the result successfully indicated the presence of nuclear material. While nuclear material could also be detected when displaced by 7.5 cm from the center, the evaluation-value decreased. Since the evaluation-value also changes depending on the mass of nuclear material, this value cannot indicate such misalignment. Therefore, in this study, we investigated a new evaluation approach using Fast Fourier Transform (FFT) analysis. Preliminary analysis found that this approach has potential to demonstrate the off-center distribution of nuclear material.

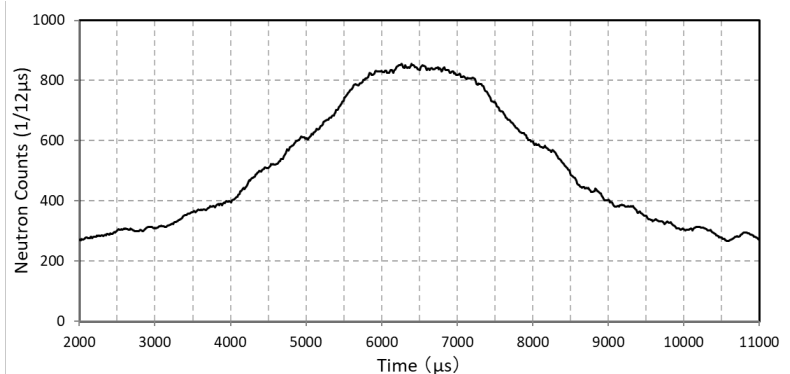


Fig. 1. Neutron count distribution measured at 4000 rpm with nuclear material

***In situ* visualization of the neutron-sensitizing reagent, *p*-borono-L-phenylalanine (BPA), absorbed in green wood cutting of red wine grape by a boron neutron capture reaction.**

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INTRODUCTION: Vegetative propagation is a form of asexual reproduction that produces new individuals from vegetative organs such as roots, stems, or branches. Unlike seed propagation, it ensures the inheritance of superior parental traits without genetic variation, making it indispensable for stable, uniform-quality crop production, particularly in polyploid fruit trees such as strawberries, bananas, and apples. However, crossbreeding remains the primary method of genetic improvement for these fruit trees, in which seed propagation is difficult, posing a challenge to the rapid development of new cultivars capable of overcoming climate change. We have been investigating the application of boron-neutron capture (BNC) reactions for mutation breeding in rice and confirmed that *p*-borono-L-phenylalanine (BPA), a neutron sensitizer, translocates to rice embryos [1, 2]. Subsequently, we successfully obtained various rice mutants exhibiting phenotypes such as dwarfism. These results suggest that BNC-mediated mutagenesis is an effective approach for cultivating seed-propagated crops. However, its applicability to vegetatively propagated plants has not yet been explored. If effective, it could provide a high-efficiency mutation breeding method for such species. Therefore, this study aimed to investigate whether green wood cuttings of the red wine grape Merlot can absorb BPA and whether the sensitizer accumulates in the emerging bud, which is essential for inducing mutations in vegetatively propagated plants.

EXPERIMENTS: *In situ* visualization of BPA in green wood cuttings of red wine grapes> Green wood cuttings of red wine grapes, Merlot (*Vitis vinifera* L. cv. Merlot) were immersed in BPA solution. (500 ppm) for 24 hrs. Slices (10- μ m thickness) of an emerging bud of the green wood cuttings were mounted onto a solid-state nuclear tracking detector, CR-39 (20 mm \times 30 mm), and irradiated with epithermal neutrons for 20 min by applying them to the pneumatic tube in the graphite thermal column (Tc-Pn) of KUR. The irradiated CR-39 plate was etched in 6 M NaOH solution for 60 min at 70°C and was observed under an optical microscope.

RESULTS: Both Fig. 1(A) and 1(B) show close-up images of cross-sections prepared from the same emerging bud of a green wood cutting of red wine grape. Fig. 1(A) and 1(B) show a bright-field image and an α -tracking autoradiograph generated by the BNC reaction, respectively. As shown in Fig. 1(B), many etch pits derived from BPA were imaged throughout the section as small black dots that accumulated in the central part of the emerging bud.

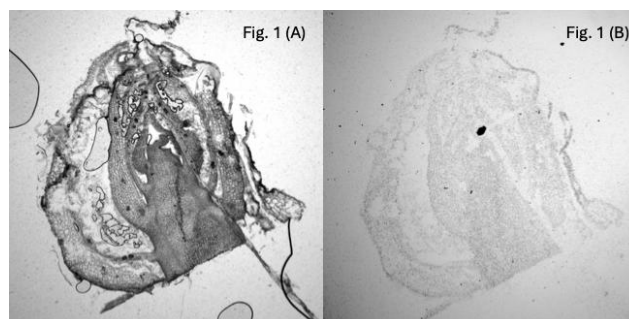


Fig. 1. Detection of BPA absorbed into the green wood cutting of red wine grapes.

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- [1] Y. Hattori *et al.*, KURNS Prog. Rep. 2024 (2025) 165.
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In-situ Porosity Distribution Evaluation of Additively Manufactured Workpiece During Tensile Test Using Neutron Phase Imaging

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INTRODUCTION: Inspection for voids is necessary in metal additive manufacturing (AM) because significant variations in the internal void distribution can occur, potentially affecting quality aspects such as mechanical properties. Previous research has suggested that phase imaging using neutron beams may enable identification of relative differences in void fraction between samples. Therefore, in this report, we investigate the changes in porosity and pore size under tensile loading.

EXPERIMENTS: The experimental setup is shown in Fig.1. Using 1-mm-thick plate-shaped test specimens fabricated by the Powder Bed Fusion (PBF) method, the porosity and pore size under tensile loading were measured using neutron phase imaging. Porosity and pore size were measured under four conditions: no load, elastic deformation, yield point, and maximum load. In-situ observations were conducted while maintaining tensile loads corresponding to each condition, specifically 0, 1500, 3000, and 3500 N.

RESULTS: Figure 2 shows the spatial distribution of porosity measured using neutron phase imaging. As shown in Fig. 2, a trend was observed throughout the evaluation region in which porosity increased with increasing tensile load. In particular, as shown in Fig. 2(c) and (d), it can be seen that porosity increases significantly from the point at which the tensile load reaches the yield point up to the maximum load. Furthermore, the porosity is higher near $X = 2.0$ [mm] and $Y = 2.5$ [mm] than in other regions. Thus, this result confirmed local variations in porosity within the evaluation region.

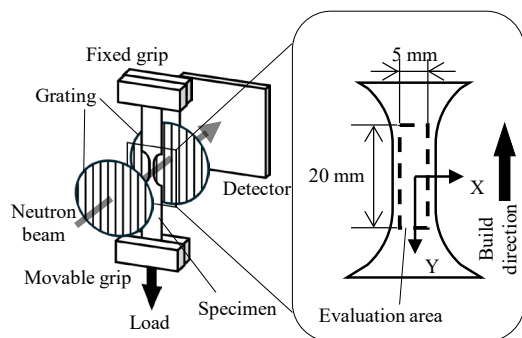


Fig.1 Experimental setup [1]

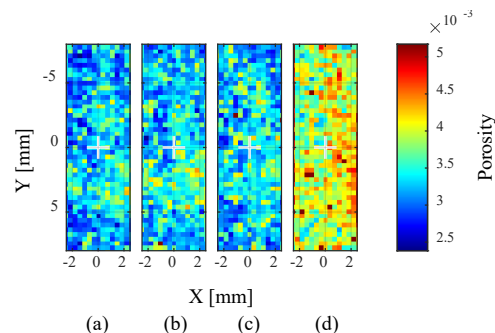


Fig.2 Porosity distribution under loads:
(a) 0 N, (b) 1500 N, (c) 3000 N, (d) 3500 N [1]

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Elucidation of the mechanism of degradation of the tumor suppressor p53, which is dependent on human papillomavirus protein E6.

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INTRODUCTION: It is known that E6AP (E6-associated protein), a kind of ubiquitin ligase, interacts with E6 protein derived from oncogenic human papilloma virus (HPV 16/18) and the enzyme complex induces ubiquitination of p53 resulting p53 degradation by ubiquitin-proteasome system. To understand the mechanism of p53 ubiquitination by E6AP and E6, we use HS-AFM to observe the structural dynamics of the E6AP/E6 complex. In addition to HS-AFM observation, we analyze the structural dynamics of the E6AP/E6/p53 complex using small-angle X-ray scattering (SAXS) methods.

EXPERIMENTS : SAXS and ultracentrifugation analysis of E6AP in FY2024 revealed that purified E6AP was contaminated with partially degraded E6AP, which interfered with the SAXS measurement of full-length E6AP. Therefore, in FY2025, we attempted to improve the method for preparing highly purified full-length E6AP. E6AP had previously been expressed as a recombinant protein in *E. coli* and then purified, but the expression host was changed to animal cells. An extracellular secretion signal was added to the E6AP gene and incorporated into the expression vector pcDNA3.4. This plasmid vector was then transfected into HEK293T cells to induce transient expression of the E6AP protein. E6AP expression and secretion into the culture medium were verified by Western blotting.

RESULTS : Confirmation of E6AP protein expression in the culture medium revealed that the amount of E6AP protein in the medium was extremely small. Therefore, intracellular expression was investigated instead of secretion into the culture medium. The confirmation of E6AP protein expression within cells suggests that secretion into the culture medium via a secretory signal was not very effective. The secretory signal into the culture medium was added to facilitate protein purification, but since intracellular expression is more prevalent, the possibility of purifying the E6AP protein after cell disruption is also considered. However, Western blot analysis revealed that even in animal intracellular expression, a large amount of partially degraded E6AP exists, similar to the expression in *E. coli*. Therefore, in order to purify the full-length E6AP protein, we plan to create a plasmid vector in which a FLAG tag is introduced to the C-terminus of E6AP, and prepare full-length E6AP by a two-step purification using the His-tag at the N-terminus (originally added for purification) and the newly introduced FLAG tag at the C-terminus. Currently, we are working on preparing a plasmid vector in which a FLAG tag is introduced to the C-terminus.

Evaluation of Porosity Distribution in Metal Additive Manufacturing Parts Using Neutron Phase Imaging

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INTRODUCTION: Inspection for voids is necessary in metal additive manufacturing (AM) because significant variations in the internal void distribution can occur, potentially affecting quality aspects such as mechanical properties. However, conventional inspection methods such as polished cross-section observation and X-ray CT cannot adequately inspect voids within the product itself due to limitations such as the destructive nature of the process and poor penetration. Consequently, neutron phase imaging—which is non-destructive and offers high penetration—is attracting attention. To evaluate the effectiveness of neutron phase imaging in three-dimensional distribution evaluation of voids, the correspondence between scattering image and cross-sectional image was investigated.

EXPERIMENTS: The porosity of samples was measured by the neutron phase imaging [1]. The porosity was also measured from the cross-sectional image of samples taken by a digital microscope. Samples were cut, embedded into plastic pellets, and polished for observation. The cross-sectional image was binarized to extract the pore area.

RESULTS: Figure 1 shows the correspondence between scattering image and cross-sectional image. By comparing Figs.1(a) and (b), two groups of voids observed in the cross-sectional image are also observed in the scattering images. The positional correspondence of those voids seems reasonable. In principle, neutron phase imaging should not have the sensitivity to detect such large voids. However, it is estimated that such a correlation can be observed due to scattering caused by microstructures on the surface or edges of large voids. In other words, neutron phase imaging may be capable of detecting voids ranging from the microscale to the millimeter scale.

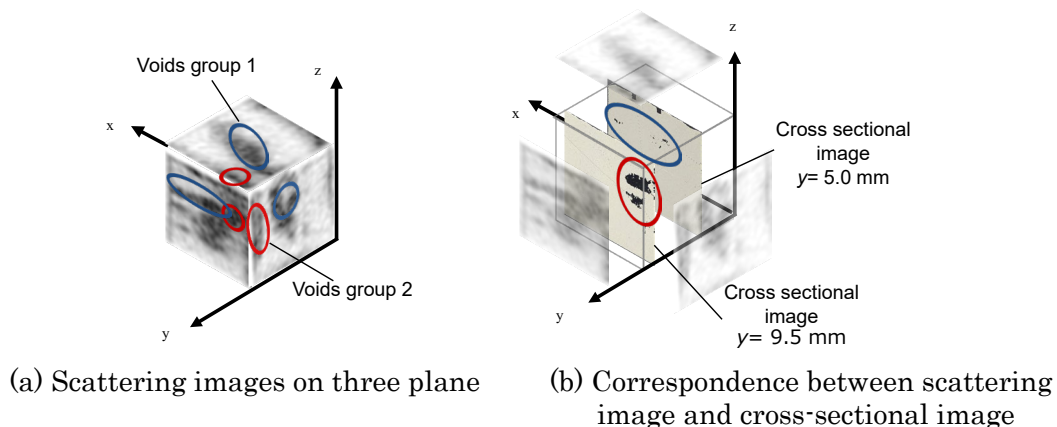


Fig.1 Estimation of three-dimensional correspondence between scattering image and cross-sectional image

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