Far-infrared metal and Dust Emission in a Galaxy at Redshift ~ 8

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When, how, and what amount of dust was formed for the first time in the Universe is one of the fundamental questions in astrophysics. Actually, significant number of detections of dust from galaxies at very early cosmic ages have been reported, pushing the age of the first dust production even back to the Epoch of Reionization. We report the Atacama Large Millimeter/submillimeter Array (ALMA) detection of the [OIII] 88 μm line and rest-frame 90 μm dust continuum emission in a *Y*-dropout Lyman break galaxy (LBG), MACS0416_Y1 lying behind the Frontier Field cluster MACS J0416.1−2403. This [O III] detection confirms the LBG with a spectroscopic redshift of z = 8.3118 ± 0.0003, making this object one of the farthest galaxies ever identified spectroscopically. The observed 850 μm flux density of 137 ± 26 μJy corresponds to a de-lensed total infrared (IR) luminosity of $L_{\rm IR} = (1.7 \pm 0.3) \times 10^{11}\ L_\odot$ if assuming a dust temperature of $T_{\rm dust}$ = 50 K and an emissivity index of β = 1.5, yielding a large dust mass of $4 \times 10^6\ M_\odot$. The ultraviolet-to-far-IR spectral energy distribution modeling where the [O III] emissivity model is incorporated suggests the presence of a young ($\tau_{\rm age} \approx 4$ Myr), star-forming (SFR ≈ 60 $M_\odot$ yr^{-1}), moderately metal-polluted ($Z \approx 0.2\ Z_\odot$) stellar component with a mass of $M_{\rm star} = 3 \times 10^8\ M_\odot$. An analytic dust mass evolution model with a single episode of star formation does not reproduce the metallicity and dust mass in $\tau_{\rm age} \approx 4$ Myr, suggesting a pre-existing evolved stellar component with $M_{\rm star} \sim 3 \times 10^9\ M_\odot$ and $\tau_{\rm age} \sim 0.3$ Gyr as the origin of the dust mass. We discuss the relative importance of dust formation in the final stage of stars and the grain growth in the ISM for these galaxies.