CENTER FOR ACCELERATOR TARGET SCIENCE

Argonne NATIONAL LABORATORY

METHOD DEVELOPMENT FOR PRODUCING THIN ^{14}C FOILS

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THE NEED FOR ^{14}C TARGETS

- High value as neutron-rich, low-Z target for nuclear physics experiments:
  - Recent experiments aimed to use the ^{24}Mg + ^{12}C fusion reaction to perform detailed γ-ray spectroscopy studies of the astrophysically important nuclei ^{34}Ar and ^{34}Cl.
  - Investigations of excited-state lifetimes and related properties following single-neutron transfer in the inverse-kinematic $^{13}C(^{138}Ba,^{12}C\gamma)^{139}Ba$ and $^{13}C(^{140}Ce,^{12}C\gamma)^{141}Ce$ reactions near the barrier.
  - Measurements of the lifetimes of states in $^{59,60}Fe$ (N = 33; 34) using the Doppler Shift Attenuation Method (DSAM) technique. A highly inverse reaction, $^{14}C(^{48}Ca,xn)$ is proposed in order to increase sensitivity for shorter half-lives.

^{14}C STOCK AT ARGONNE NATIONAL LAB

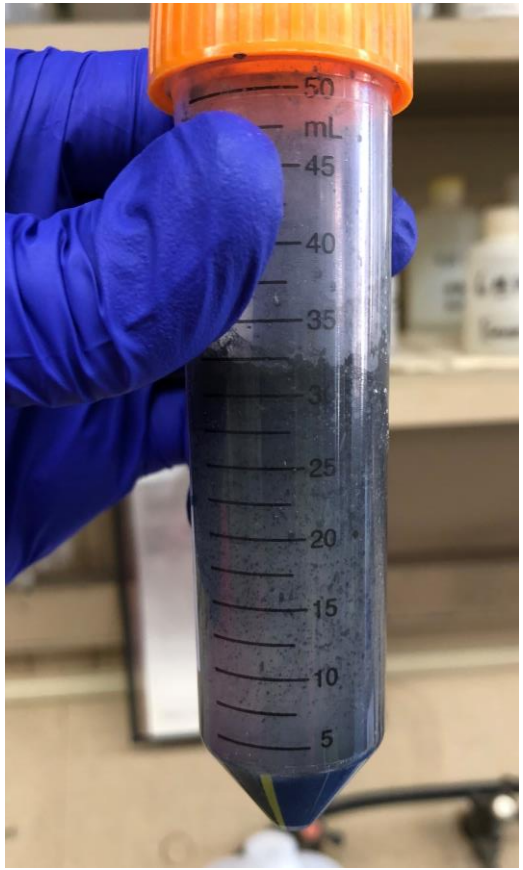
- Leftover targets from the pion program at LAMPF (LANSCE)
- Originally contained in two target cells
  - 5 x 5 x 0.6 cm
  - Copper frame with thin nickel windows
- ~35 Ci (1.3 TBq) of ^{14}C
- Composition:
  - 75% ^{14}C
  - 16% ^{12}C
  - 9% Impurities

NECESSITY TO PURIFY ^{14}C STOCK MATERIAL

- 9% Impurities Include:
  - SiO_2
  - MgO
  - Al_2O_3
- Unsure of the relative abundance of each
- Take advantage of relative inertness of graphite
- Dissolve and decant away impurities
- Method must be glove box friendly

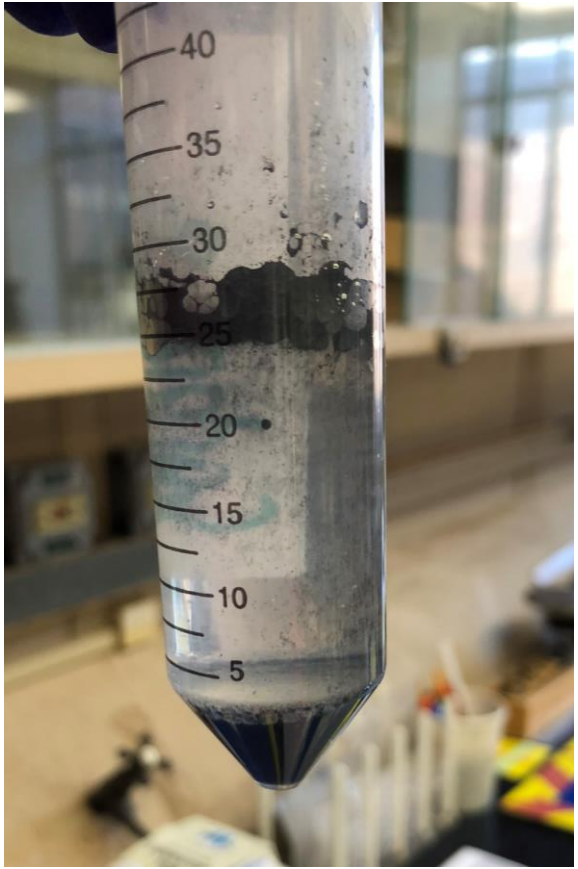
PURIFICATION

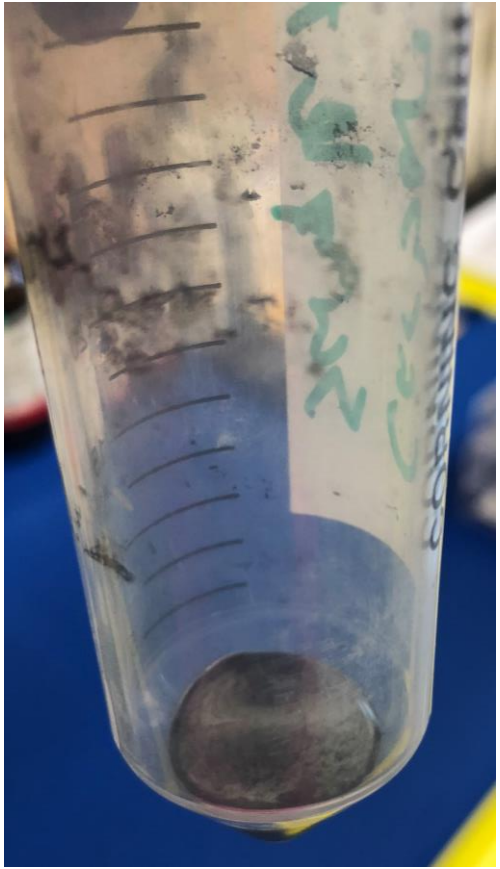
- Suspension of material in 50% w/w NaOH solution.
- Shaken vigorously to ensure homogenous contact.
- Allowed to settle overnight
- Frothy third layer formation



PURIFICATION – OXIDE LAYER REMOVAL

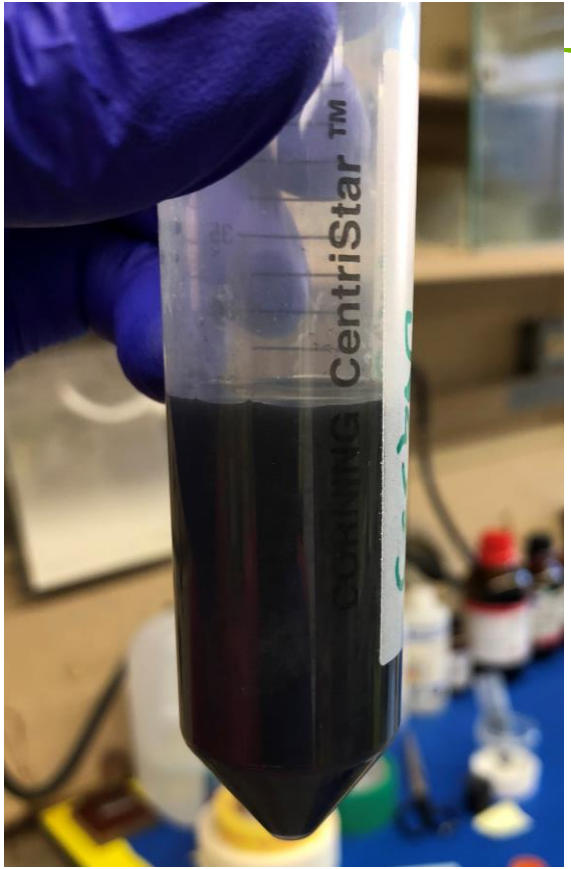
- Settling resulted oxide layer on top of carbon powder
- Two samples treated differently:
  - One with the oxide layer left intact
  - One with the oxide layer carefully pipetted away

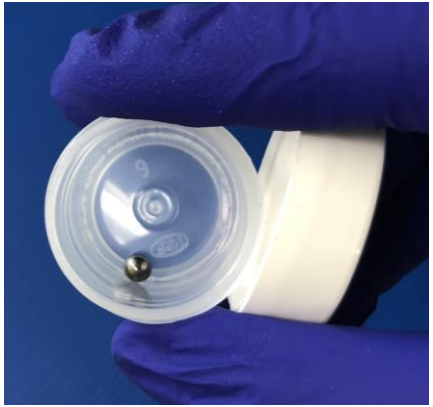




PURIFICATION

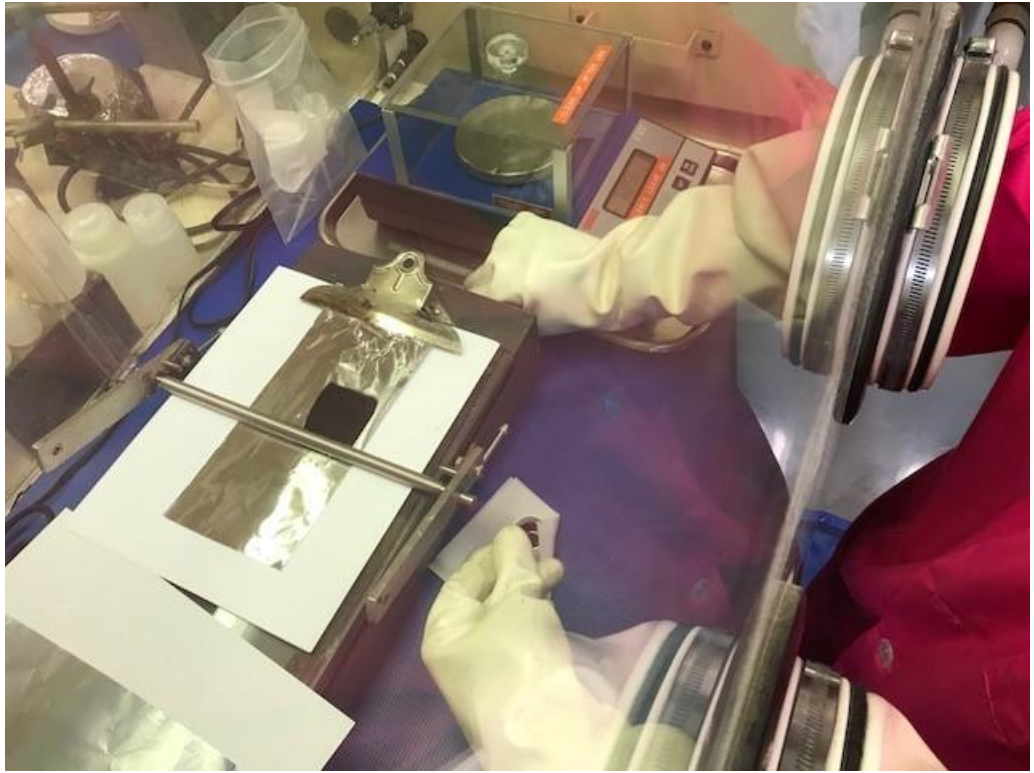
- Washed and decanted three times with DI H_2O
- Transferred using a small volume of ethanol
- Allowed to dry in poly vial before dry down printing





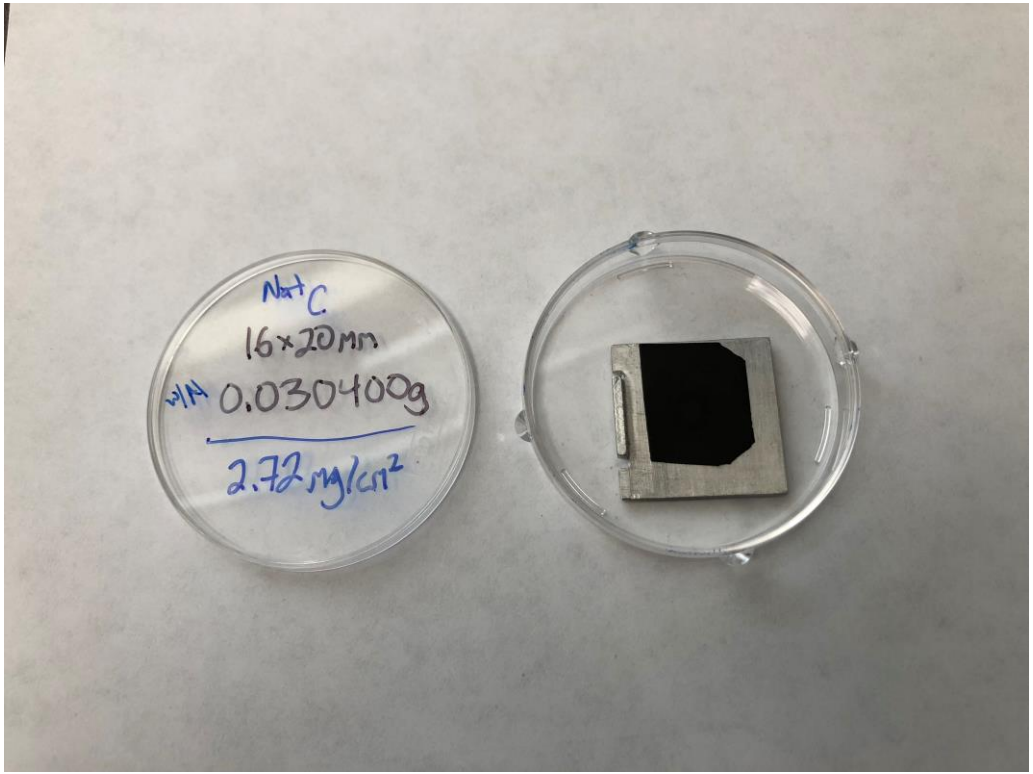
DRY DOWN PRINTING METHOD

- Carbon combined with isopropanol and EC300-BOE binder
- Mixed at high speed for 3 x 15 seconds to homogenize the carbon “paint”
- Pipetted aliquot across the surface of Al foil
- Use draw-down machine to “print” carbon on the foil



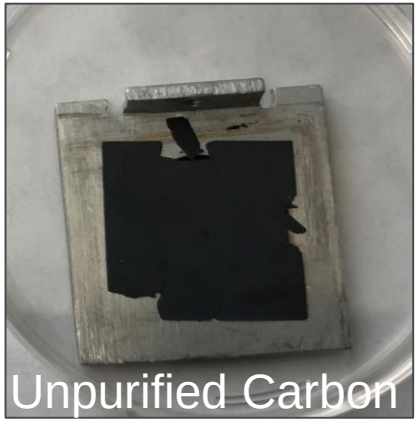
DRY DOWN PRINTING METHOD

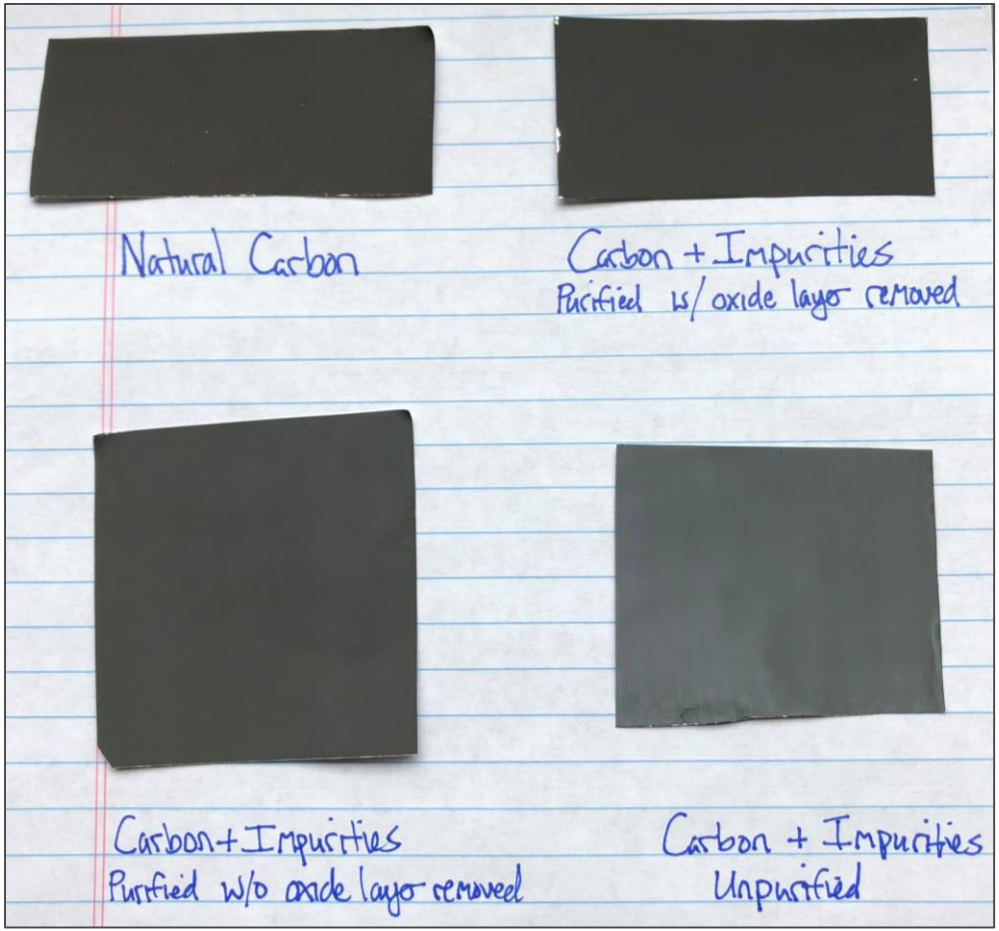
- Foil allowed to air dry and then baked in an oven
- Finished foil cut into target-sized pieces
- Aluminum backing etched away in 50% w/w NaOH
- Mounted on frames from H_2O



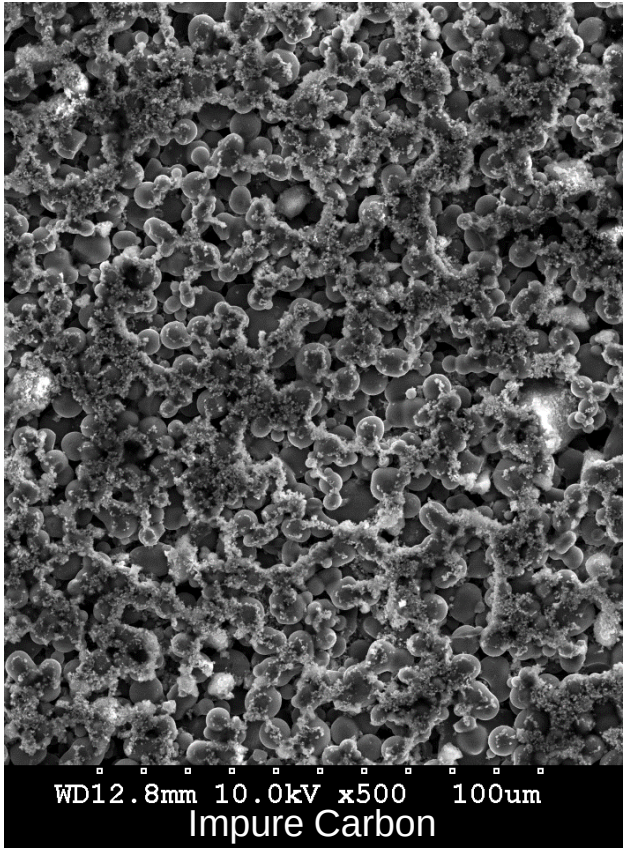
COMPARISON OF PRODUCED TARGETS

- Visually can see diminished impurities
- Physically higher impurities exhibit greater brittleness

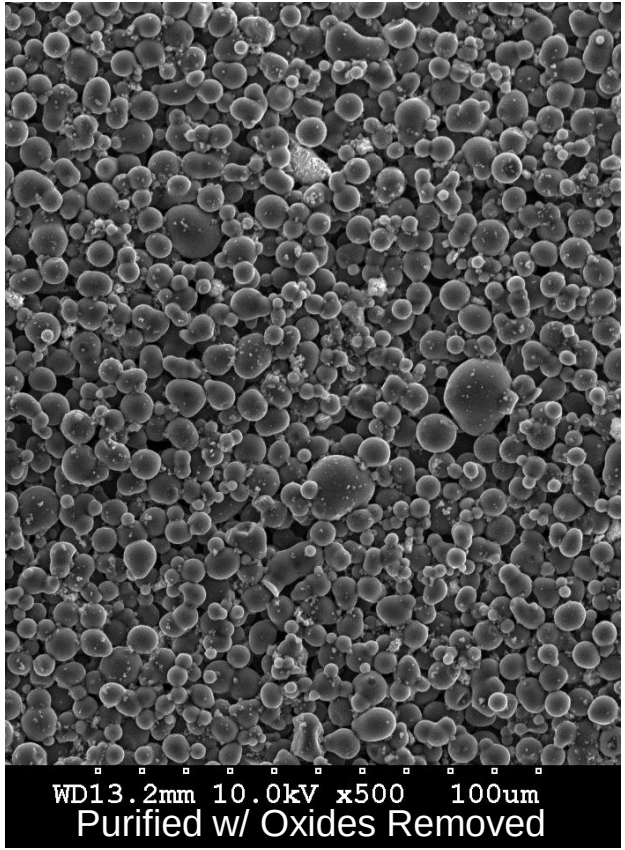




SEM OF IMPURE CARBON VS PURIFIED

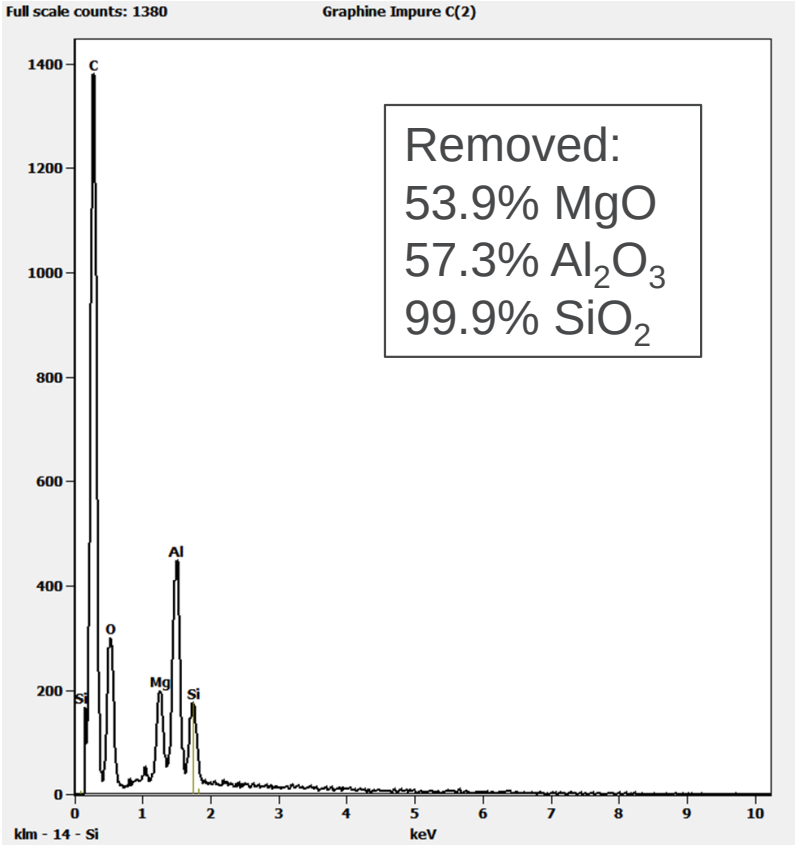


Impure Carbon

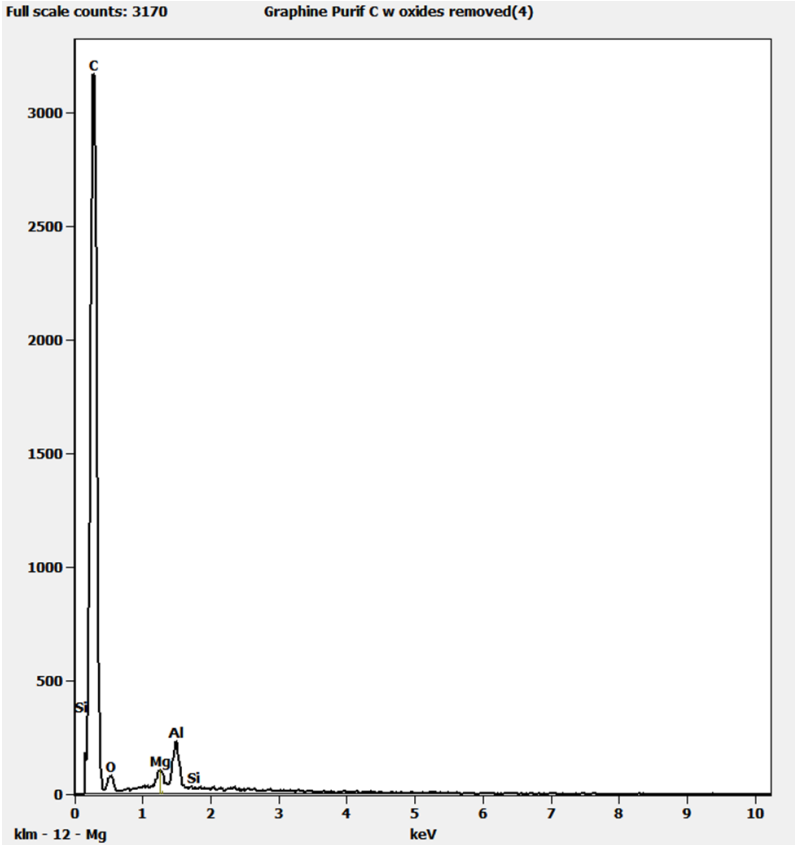


Purified w/ Oxides Removed

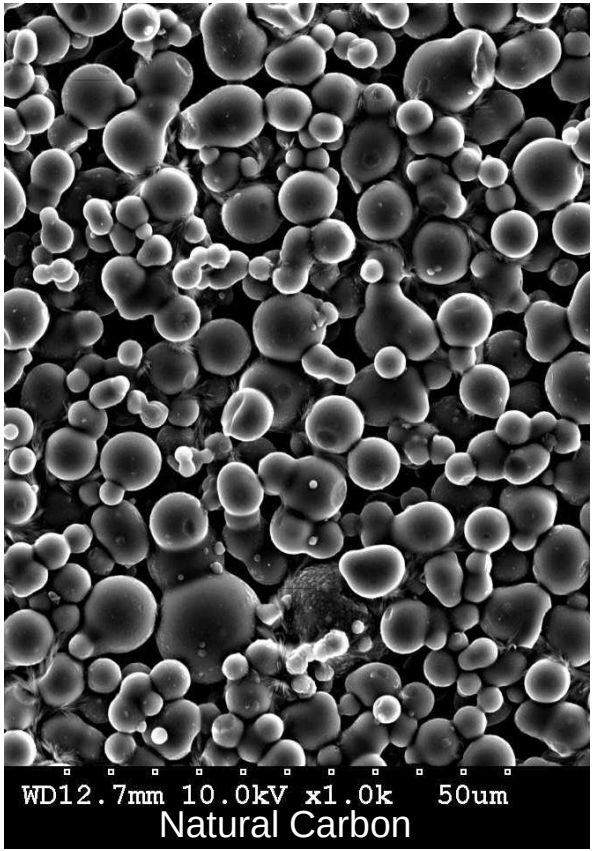
RELATIVE REDUCTION OF IMPURITIES



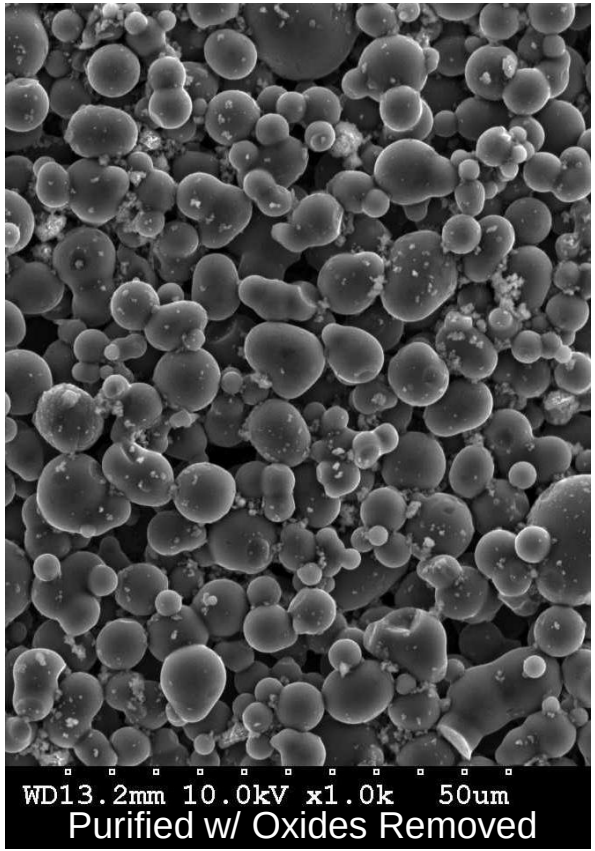
Removed:
53.9% MgO
57.3% Al_2O_3
99.9% SiO_2



NATURAL CARBON VS PURIFIED CARBON

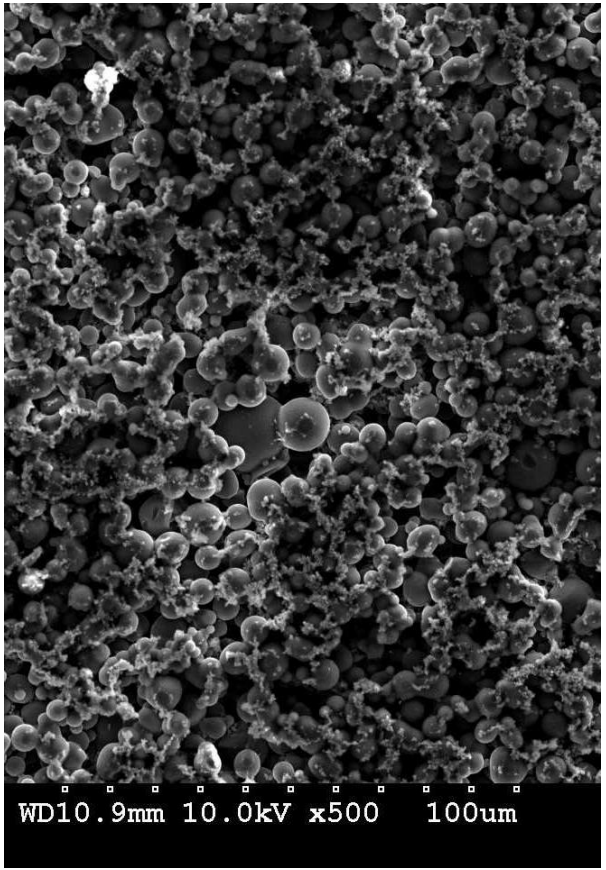


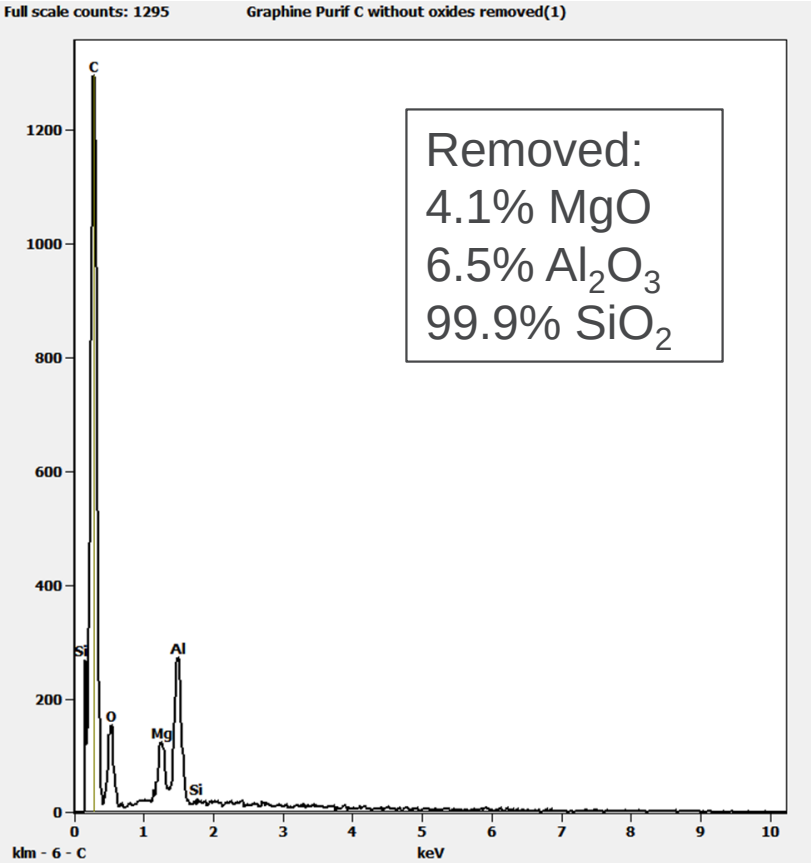
Natural Carbon



Purified w/ Oxides Removed

DIFFERENCE OF OXIDE REMOVAL





SUMMARY

- ^{14}C targets are of high value for nuclear physics research
- Simple dissolution based method can quickly remove the bulk impurities
- Dry-down method enables preparation of relatively thin carbon targets
- Reduced impurities improve foil stability
- Method suitable for applying to ^{14}C for target production

ACKNOWLEDGMENTS

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THANK YOU FOR YOUR ATTENTION