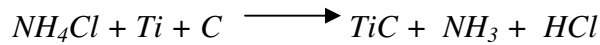


APPENDICES

Appendix 1:

Calculation of the amount of powder required to achieve a 1 μ m TiC coating on 2 μ m diamond powder.

Molar mass of Ti = 48g, Molar mass of C = 12g, Molar mass of O₂ = 32g, Molar mass of NH₄Cl = 53g, Density of TiC = 4.93g/cm³, Density of Diamond = 3.54g/cm³.



$$\text{Unit volume of diamond (U)} = \frac{1g}{\text{density}} = \frac{1}{3.54} = 0.282\text{cm}^3$$

$$\text{Volume of diamond grain} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \left(\frac{0.0002}{2}\right)^3 = 4.19 \times 10^{-12} \text{cm}^3$$

$$\text{Number of particles per g of diamond (n)} = \frac{\text{UnitVol.}}{\text{Vol.ofgrain}} = 6.74 \times 10^{10}$$

$$\begin{aligned} \text{Therefore: Specific surface area of diamond (SSA)} &= 4\pi r^2 \times \text{No. of particles per gram (n)} \\ &= 8.47 \times 10^3 \text{cm}^2/\text{g} \end{aligned}$$

$$\begin{aligned} \text{Vol. of coating per g of diamond powder (V)} &= \text{SSA} \times \text{thickness of coating on diamond} \\ \text{(t)} &= 8.47 \times 10^3 \text{cm}^2/\text{g} \times 1 \times 10^{-4} \text{cm} \\ &= 8.47 \times 10^{-1} \text{cm}^3 \end{aligned}$$

$$\begin{aligned} \text{Mass of TiC per g of diamond} &= \text{density of coating compound} \times \text{vol. of coating per g of} \\ \text{diamond} &= 4.18\text{g} \end{aligned}$$

$$\text{Vol. fraction of TiC} = \frac{V}{V+U} = 0.75$$

Therefore: Vol. fraction of diamond (ignoring porosity) (V_p) = $1-0.75 = 0.25$

Assuming 50% porosity of the preform:

$$\text{Vol. fraction of diamond prior to infiltration (porosity included)} = V_p \times (1-0.5) = 0.125$$

$$\text{Estimated vol. of sample (preform)} = \pi r^2 h = \pi (0.9)^2 \times 0.5 = 1.272\text{cm}^3$$

$$\text{Therefore: Vol. of diamond in the sample} = 0.125 \times 1.272 = 0.159\text{cm}^3$$

$$\begin{aligned} \text{Therefore: Mass of diamond in the sample} &= \text{Vol.} \times \text{Density} = 0.159 \times 3.52 \\ &= 0.560\text{g} \end{aligned}$$

$$\begin{aligned} \text{Final vol. of TiC in the sample (porosity included)} &= \text{Vol. fraction of TiC} \times \text{Porosity} \\ &= 0.75 \times 0.5 \\ &= 0.375 \end{aligned}$$

$$\begin{aligned} \text{Therefore: Vol. of TiC in sample} &= \text{vol. frac. of TiC} \times \text{vol. of sample} \\ &= 0.375 \times 1.272\text{cm}^3 \\ &= 0.477\text{cm}^3 \end{aligned}$$

$$\begin{aligned} \text{Hence: Mass of TiC in the sample} &= \text{vol. of TiC} \times \text{density of TiC} \\ &= 0.477\text{cm}^3 \times 4.93\text{g/cm}^3 \\ &= 2.352\text{g} \end{aligned}$$

$$\text{Therefore: Mass of Ti in the sample} = 2.352 \times \frac{48}{60} = \underline{\underline{1.882\text{g}}}$$

$$\text{Hence: Balance C from TiC} = 2.352 - 1.882 = 0.470\text{g}$$

Therefore: **Total mass of C (diamond) in the sample** = $0.470\text{g} + 0.560\text{g} = \underline{\underline{1.030\text{g}}}$

Ratio of reacting moles from the equation = $\text{Ti} : \text{NH}_4\text{Cl} = 1:1$

Moles of Ti that reacted = Moles of NH_4Cl that reacted = $\frac{1.882}{48} = 0.0392$ moles

Hence: **Mass of NH_4Cl reacted** = moles \times Mr = $0.0392 \times 53\text{g} = \underline{\underline{2.078\text{g}}}$

Therefore the required quantities of the powders are: **Diamond = 1.030g**

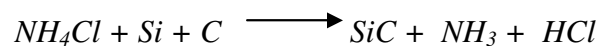
: Ti = 1.882g

: NH_4Cl = 2.078g

Appendix 2:

Calculation of the amount of powder required to achieve a $1\mu\text{m}$ SiC coating on $2\mu\text{m}$ diamond powder.

Molar mass of Si = 28g, Molar mass of C = 12g, Molar mass of O_2 = 32g, Molar mass of NH_4Cl = 53g, Density of SiC = 3.16g/cm^3 , Density of Diamond = 3.54g/cm^3 .



Unit volume of diamond (U) = $\frac{1\text{g}}{\text{density}} = \frac{1}{3.54} = 0.282\text{cm}^3$

$$\text{Volume of diamond grain} = \frac{4}{3} \pi r^3 = \frac{4}{3} \pi \left(\frac{0.0002}{2} \right)^3 = 4.19 \times 10^{-12} \text{ cm}^3$$

$$\text{Number of particles per g of diamond (n)} = \frac{\text{UnitVol.}}{\text{Vol.ofgrain}} = 6.74 \times 10^{10}$$

Therefore: Specific surface area of diamond (SSA) = $4\pi r^2 \times \text{No. of particles per gram (n)}$
 $= 8.47 \times 10^3 \text{ cm}^2/\text{g}$

Vol. of coating per g of diamond powder (V) = SSA x thickness of coating on diamond
 (t) $= 8.47 \times 10^3 \text{ cm}^2/\text{g} \times 1 \times 10^{-4} \text{ cm}$
 $= 8.47 \times 10^{-1} \text{ cm}^3$

Mass of SiC per g of diamond = density of coating compound x vol. of coating per g of diamond
 $= 2.68 \text{ g}$

$$\text{Vol. fraction of SiC} = \frac{V}{V+U} = 0.75$$

Vol. fraction of diamond (ignoring porosity) (V_p) = $1 - 0.75 = 0.25$

Assuming 50% porosity of the preform:

Vol. fraction of diamond prior to infiltration (porosity included) = $V_p \times (1 - 0.5) = 0.125$

Estimated vol. of sample (preform) = $\pi r^2 h = \pi (0.9)^2 \times 0.5 = 1.272 \text{ cm}^3$

Therefore: Vol. of diamond in the sample = $0.125 \times 1.272 = 0.159 \text{ cm}^3$

Therefore: Mass of diamond in the sample = Vol. x Density = 0.159×3.52
 $= 0.560 \text{ g}$

Final vol. of SiC in the sample (porosity included) = Vol. fraction of SiC x Porosity

$$= 0.75 \times 0.5$$

$$= 0.375$$

Therefore: Vol. of SiC in sample = vol. frac. of SiC x vol. of sample

$$= 0.375 \times 1.272\text{cm}^3$$

$$= 0.477\text{cm}^3$$

Hence: Mass of SiC in the sample = vol. of SiC x density of SiC

$$= 0.477\text{cm}^3 \times 3.16\text{g/cm}^3$$

$$= 1.507\text{g}$$

Therefore: **Mass of Si in the sample** = $1.507 \times \frac{28}{40} = \underline{\underline{1.055\text{g}}}$

Hence: Balance C from SiC = $1.507 - 1.055 = 0.452\text{g}$

Therefore: **Total mass of C (diamond) in the sample** = $0.452\text{g} + 0.560\text{g} = \underline{\underline{1.012\text{g}}}$

Ratio of reacting moles from the equation = Si : NH₄Cl = 1:1

Moles of Si that reacted = Moles of NH₄Cl that reacted = $\frac{1.055}{28} = 0.0377$ moles

Hence: **Mass of NH₄Cl reacted** = moles x Mr = $0.0377 \times 53\text{g} = \underline{\underline{1.998\text{g}}}$

Therefore the required quantities of the powders are: **Diamond = 1.012g**

: Si = 1.055g

: NH₄Cl = 1.998g