

X-ray Irradiation for Virus Inactivation

X-ray irradiation has become a crucial tool for virus inactivation, balancing effective pathogen neutralization with or without the preservation of viral structural integrity. This technique is widely employed in virology for applications such as vaccine development, diagnostic research, and the safe handling of pathogenic samples.

The significance of X-ray irradiation is underscored by its ability to inactivate viruses with or without compromising their biochemical and immunological characteristics. Research has demonstrated that optimized X-ray doses effectively inactivate zoonotic RNA viruses, such as Zika, Hazara, Bebaru, and Rift Valley Fever (*Afrough, et al, 2020*). Moreover, X-ray irradiation facilitates the safe transfer and analysis of inactivated viruses in laboratories with lower biosafety levels.

Classification of Viral Resistance to Irradiation

Viruses exhibit varying degrees of resistance to ionizing radiation, primarily influenced by their genomic composition and structural complexity:

- **High Resistance:** Prion diseases such as kuru, Creutzfeldt-Jakob disease, and scrapie exhibit extreme resistance to ionizing radiation. Even high doses (up to 200 kGy) have shown minimal reduction in viral titers, suggesting a unique structure compared to other mammalian viruses.
- **Moderate Resistance:** Non-enveloped viruses, including adenoviruses and parvoviruses, demonstrate moderate resistance due to their robust capsid structures.
- **Low Resistance:** Enveloped viruses such as influenza and herpesviruses are more susceptible to irradiation, as their lipid envelopes are prone to damage.

Applications of X-ray Irradiation in Virology (Figure 1)

X-ray irradiation serves multiple critical functions in virology, including:

1. **Complete Inactivation for Safety:** Ensuring complete virus inactivation is essential for safe handling and study. X-ray irradiation has been used to inactivate high-consequence pathogens, such as Ebola and Lassa viruses, making them safer for research in standard laboratory conditions.
2. **Facilitating Research in Lower Biosafety Laboratories:** Inactivating viruses enables their safe transfer to lower biosafety-level labs, reducing the need for high-containment facilities while allowing broader research access.
3. **Studying Viral Pathways:** X-ray irradiation allows researchers to investigate viral entry mechanisms, replication processes, and interactions with host cells without infection risks.
4. **Sequencing and Genomic Studies:** By inactivating viruses, irradiation enables safe viral nucleic acid extraction and sequencing, aiding genomic research and the development of molecular diagnostics.

5. **Vaccine Development:** X-ray irradiation is used to inactivate viruses while preserving their immunogenicity, which is essential for developing vaccines that induce strong immune responses without causing disease.

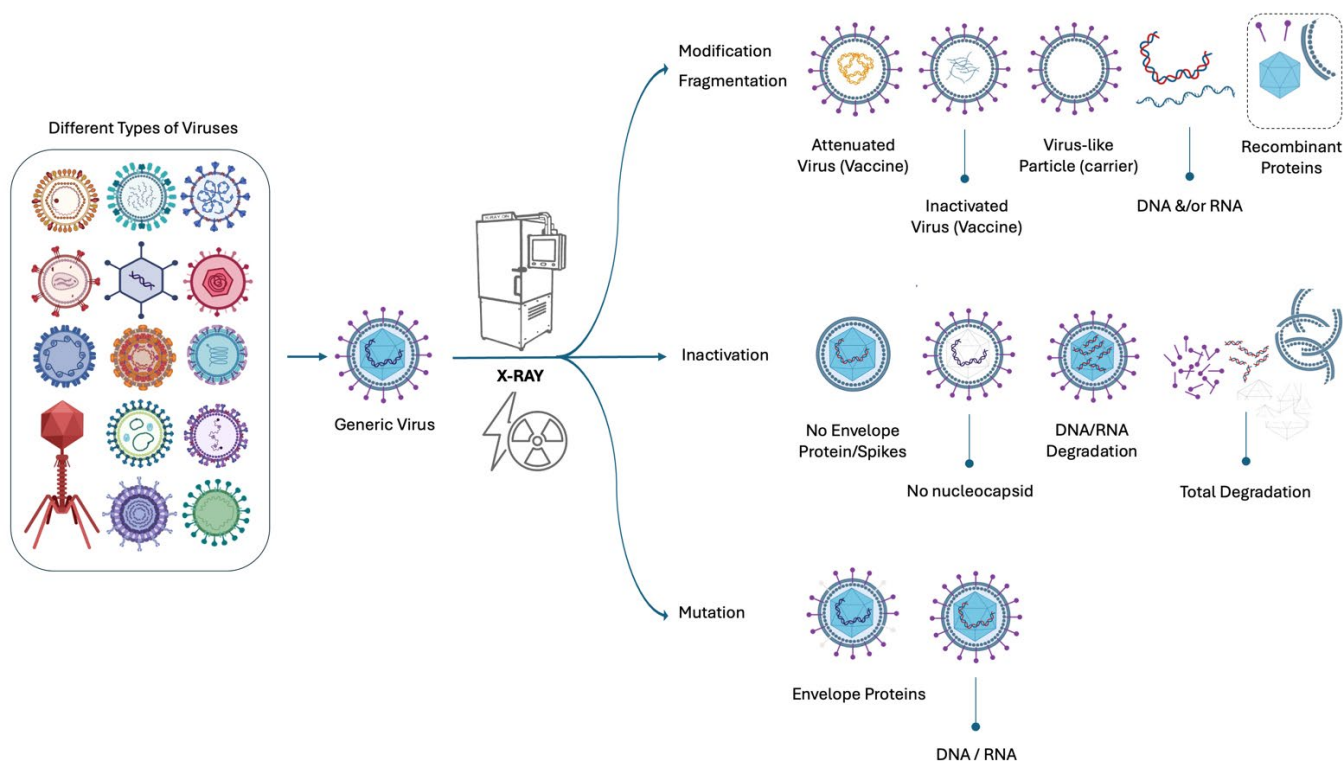


Figure 1. Applications of X-ray Irradiation in Virology.

Virus Inactivation Research Utilizing Precision X-Ray, Inc. Systems

Precision X-Ray, Inc. systems have been instrumental in virology research, providing precise and reliable irradiation capabilities. As an example, Afrough et al (2020) at the National Infection Service, the Centre for Chemical, Radiation and Environmental Hazards at Public Health England, and the CBR Division, Defense and Science Technology Laboratories in England, utilized a **MultiRad 225** to explore X-ray inactivation of RNA viruses without loss of biological characteristics.

This study defines the amount and type of X-ray radiation needed to create replication-deficient versions of several viruses while maintaining their key biochemical and immunological properties. These viruses can then be used in detection and functional assays, offering a reliable way to produce non-infectious reagents for diagnostics and R&D in lower containment labs.

The results showed that X-ray inactivation can be effectively achieved for a range of medically important zoonotic viruses. X-ray irradiation is a reliable method for pathogen inactivation, allowing the production of non-infectious whole-virus material that retains its key biochemical and immunological properties

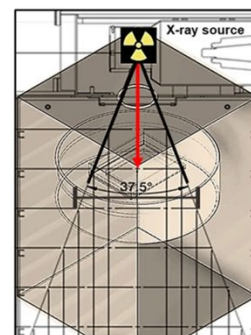
under standard inactivation conditions. These findings provide a unique tool for quickly developing reagents for various downstream applications in a safe and reproducible way.

a

Virus	Sample condition	X-ray D-value	Inactivation dose [†]	Time [‡] (min)	In vitro CPE*	Gamma D-value
ZIKV-X	Ambient (+18°C)	1.83 kGy	12.86 kGy	432.12	0/3 (Vero)	1.80 – 8.60 kGy ⁵¹
ZIKV-X	Frozen (-30°C)	2.94 kGy	20.58 kGy	691.53	0/3 (Vero)	3.37 kGy ⁵⁸
RVFV-X	Ambient (+18°C)	2.63 kGy	18.42 kGy	618.95	0/3 (Vero)	
RVFV-X	Frozen (-30°C)	3.84 kGy	26.92 kGy	904.57	0/3 (Vero)	< 2.0 - 2.60 kGy ^{50,59}
HAZV-X	Ambient (+18°C)	0.96 kGy	6.72 kGy	225.81	0/3 (SW13)	
BEV-X	Ambient (+18°C)	4.38 kGy	30.71 kGy	1031.92	0/3 (BHK-21)	3.87 – 5.43 kGy ⁵¹

*Denotes end-point data recorded after three weeks of serial passage in triplicate
[†]Dose required to achieve 7-log₁₀ reduction of TCID₅₀ infectious titre
[‡]Time defined at a dose rate of 0.496 Gy/s

c



a. Inactivation of viral pathogens using X-rays. X-ray D-values showing the dose required to inactivate 1-log₁₀ of virus at 220 keV, 17.5 mA with 0.2 mm Al filtration. X-ray D-values were then compared to gamma inactivation data produced under similar sample conditions, for members of the same genus. **c. Effect of X-ray beam filtration on ZIKV inactivation.** The irradiation chamber showing the sealed virus specimens with packaging dimensions of 10 cm × 8 cm × 1 cm (L x W x D) at a distance of 22.6 cm within a 37.5° irradiation cone produced by the MXR-225/26 tube. Adapted from: Afrough, et al. (2020).

Conclusion

X-ray irradiation remains a versatile and effective tool in virology, enabling the safe and efficient inactivation of viruses. Its applications range from vaccine development to fundamental virology research, contributing significantly to public health and scientific advancement. Precision X-Ray, Inc. systems such as the X-RAD 320 or MultiRad 225 continue to play a crucial role in advancing virological studies by providing precise irradiation capabilities for a variety of research applications.

References

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