The present invention in particular results from the observation of the striking improvement in the purification of enveloped viruses when acid buffers are used during anion exchange chromatography. The object of the invention is therefore a process for purifying enveloped viruses comprising an anion exchange chromatography, the buffers used during said chromatography being of a pH of less than 6.

In particular, the pH may notably be comprised between 5.5 and 6. According to an alternative, the pH of the buffers used during anion exchange chromatography is greater than or equal to 6 and further comprises a polyol.

Accordingly, in one aspect, there is provided a process for purifying a pseudotyped retrovirus, in particular a pseudotyped lentivirus, comprising an anion exchange chromatography step, the buffers used during said chromatography being of a pH comprised between 5 and 5.9, or of a pH comprised between 6 and 8 and further comprising a polyol.

The inventors were able to show that by adding a polyol in one or several of the buffers used during one or several steps of a process for purifying an enveloped virus, it was possible to obtain a substantial increase in the purification yield. In particular, the improvement of the yield of a purification comprising an ultrafiltration/diafiltration step followed by anion exchange chromatography is observed when the buffers used during this chromatography comprise a polyol.

The inventors also propose inversion of the order of the anion exchange chromatography steps and of ultrafiltration/diafiltration steps, notably a tangential flow filtration (TFF), used during the purification. The application of an ultrafiltration/diafiltration, notably a TFF, before an anion exchange chromatography allows a substantial improvement in the yield of the purification of an enveloped vector. An embodiment of the disclosure relates to a process for purifying an enveloped virus, comprising, in this order, an ultrafiltration/diafiltration step, notably a TFF step, followed by an anion exchange chromatography step.

Moreover the disclosure also relates to a process for purifying enveloped viruses, said process comprising an ultrafiltration / diafiltration step, notably a TFF step, said step being carried out by using buffers containing a polyol.

The disclosure is more particularly adapted to the purification of viruses pseudotyped with a glycoprotein derived from GaLV. Until the availability of the present disclosure, the viruses pseudotyped with this type of glycoproteins were considered as "non–purifiable". The different studies carried out on these viral vectors applied raw preparations of non–purified vectors because of the fragility of the GaLV pseudotyped vectors. Unexpectedly, the inventors were able to show a substantial improvement in the purification yield by means of

CLAIMS

1. A process for purifying a pseudotyped retrovirus, in particular a pseudotyped lentivirus, comprising an anion exchange chromatography step, the buffers used during said chromatography being
- of a pH comprised between 5 and 5.9, or
- of a pH comprised between 6 and 8 and further comprising a polyol.

2. The process according to claim 1, said anion exchange chromatography buffer(s) being of a pH comprised between 5 and 5.9 and also comprising a polyol.

3. The process according to claim 1, the pH of the buffers being comprised between 5.5 and 6, the pH being more particularly equal to 5.5 or 6.

4. The process according to any one of the preceding claims, the anion exchange chromatography step being preceded with an ultrafiltration/diafiltration step, in particular a tangential flow filtration.

5. The process according to claim 4, the ultrafiltration/diafiltration step comprising the use of one or several buffers with a pH comprised between 5.5 and 7.5 optionally comprising a polyol.

6. The process according to any one of the preceding claims, for purifying an enveloped virus from the culture medium of a cell culture of cells producing said enveloped virus, the process comprising in this order:
(a) clarification of the cell culture medium;
(b) an ultrafiltration/diafiltration step for the clarified viruses;
(c) an anion exchange chromatography; and
(d) an exclusion chromatography.

7. The process according to claim 6, step (a) being carried out by filtration of the culture medium on a retention filter for which the retention threshold is comprised between 0.2 and 0.45 μm.

8. The process according to claim 6 or 7, step (b) being carried out by means of a tangential flow filtration.

9. The process according to any one of claims 6 to 8, step (d) comprising the use of an exclusion resin having an exclusion size comprised between 300 and 1,000 kDa.

10. The process according to any one of claims 6 to 9, the resin used for the exclusion chromatography being a multimode resin, having a dual functionality of exclusion and adsorption.

11. The process according to any one of claims 1 to 10, the purified virus being produced in a neutral medium or in a moderately acid medium, in particular at a pH comprised between pH 6 and pH 7.

12. The process according to any one of claims 1 to 11, the polyol being selected from sucrose, mannitol, sorbitol and trehalose.

13. The process according to any one of the preceding claims, the polyol being present in the buffer at a concentration comprised between 1.5 % and 15 % by weight in the buffer, in particular between 2 % and 5 %, more particularly 5 %.

14. The process according to any one of claims 1 to 13, the polyol being present in the buffers used during a tangential flow filtration and an anion exchange chromatography.

15. The process according to any one of the preceding claims, the polyol being present in the buffers in all the steps of the purification process.

16. The process according to any one of the preceding claims, the buffers used during said process also comprising a magnesium salt, notably magnesium chloride, notably at a

concentration comprised between 0.1 mM and 5 mM, in particular between 1 and 3 mM, more particularly 2 mM.

17. The process according to any one of the preceding claims, , wherein the retrovirus, in particular the lentivirus, is pseudotyped with the GaLV, GaLV–TR, VSV–g or MV envelope glycoprotein.

18. The process according to any one of claims 1 to 10 and 14 to 17, wherein the anion exchange chromatography is a weak anion exchange chromatography and/or an anion exchange chromatography on a column.